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No. 6—PUNCH AND DIE WORK.

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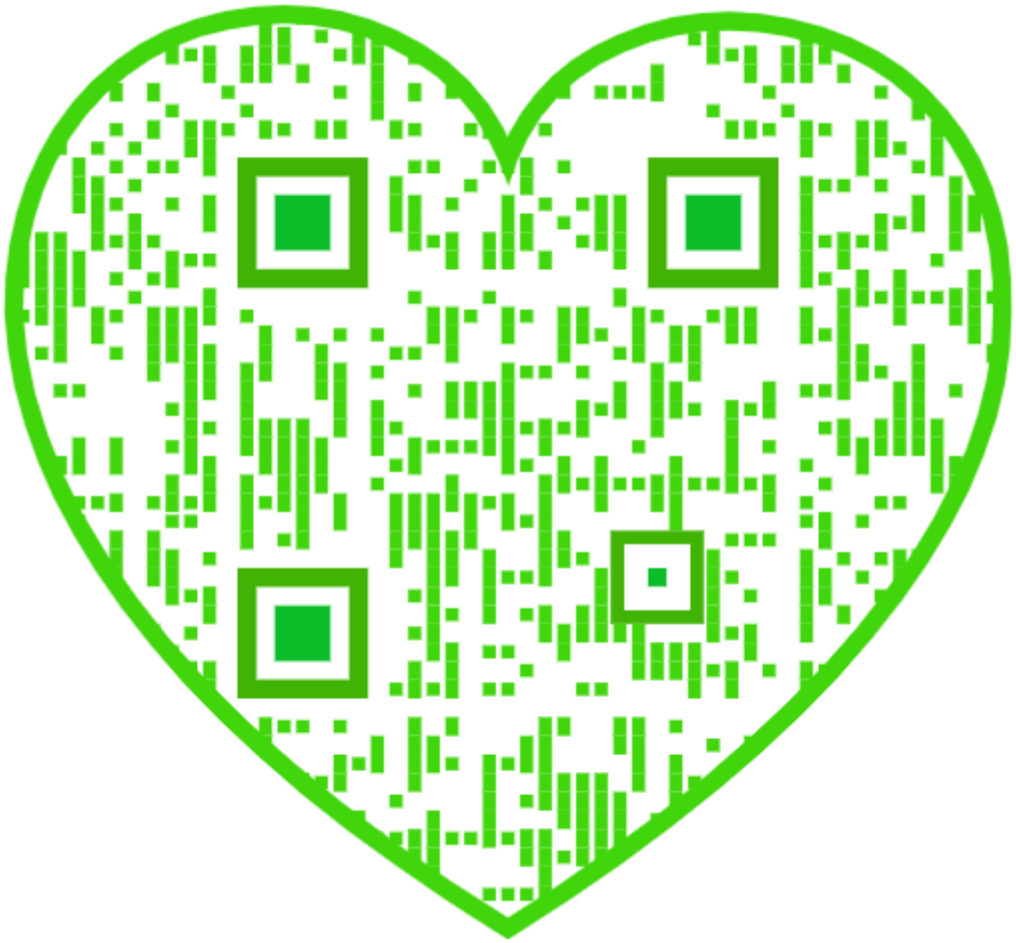

CHAPTER I.

PRINCIPLES OF PUNCH AND DIE WORK.

Under the head of punch and die work is generally included all the various tools used in blanking pieces from commercial stock; bending stock to shape; drawing out articles from sheet stock; and all the different operations performed with punching, drawing and forming presses. The most common forms of tools to be considered are the dies used for blanking articles from sheet stock, called blanking dies.

Blanking Dies.

A set of blanking dies consists of a male die, or punch, as it is generally termed, and a female die, or die block. These terms are generally abbreviated and the set is called a punch and die. Blanking dies are generally considered as belonging to one of three classes: First, plain (or simple) dies; second, gang dies; and third, compound dies.

When punches and dies are used in a punch-press, and are to constitute a part of the regular equipment of the shop, they are held in suitable permanent fixtures. Dies are held in position on the bed of the press by means of a "holdfast," the name of which differs in different shops. Some of the more common names are chair, chuck, bolster, and die holder. Dies large enough to warrant it are clamped to the bed of the press, thus doing away with the necessity for holders. Dies are fastened in place in the die holder by several methods, the most common of which is by means of screws, as shown in Fig. 1, in which *a* is the die and *b* the holder. Having screws on both sides, it is an easy matter to adjust the die, loosening the screws on one side, and forcing it over by those on the opposite side.

When the die is small, it is generally held in a shoe, as shown in Fig. 2. The manner of fastening the die in the shoe usually depends on the designer. In some shops the shoe is dovetailed as shown, the angle being from 10 degrees to 15 degrees less than a right angle; the slot is made somewhat tapering. The die is given a corresponding taper and angle on its sides, and, to fasten in position, it is driven securely in place. The amount of taper given the slot in the shoe must not be great, or the die will jar loose when in use. A taper of one-half inch per foot of length answers nicely. In other shops the shoe is made with a groove, as described above, only it is from ¼ to ⅜-inch wider than the dies, which are held in place by means of a taper key or wedge, as shown in Fig. 3. When making this form it is necessary to make the dies of equal width on their ends. This method does not require so great a degree of accuracy when machining the die block.

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A third method consists in making a shoe having the back of the slot planed at the angle mentioned, while the front wall is made square with the bottom, the die being held with setscrews, as shown in Fig. 4. If this form is used, care must be exercised when laying out the screw holes, so that they do not come in line with the screws in the bolster when the shoe is in its proper place; and, again, the screws must not press on any portion of the die immediately in line with the opening, or it will be closed somewhat when pressure is applied to the screws. Fig. 4 shows the screws pressing on the solid portion of the die.

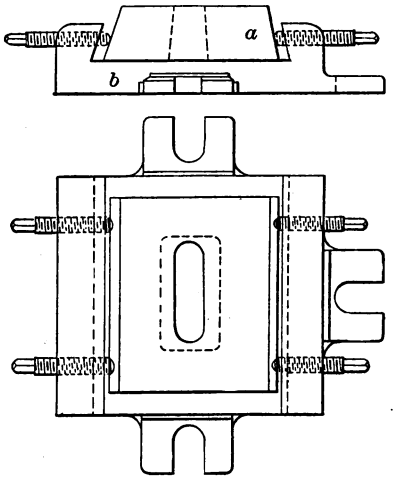

Fig. 1

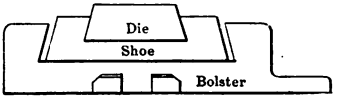

Fig. 2

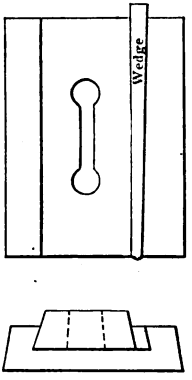

Fig. 3

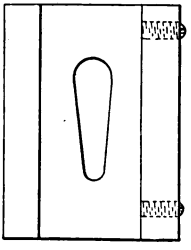

Fig. 4

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Figs. 1 to 4. Various Methods of Holding Work.

Dies which are fastened in bolsters without using a shoe must have their sides machined at an angle, as in Fig. 1, to prevent them lifting from the strain incident to removing the punch when it has pierced the stock. The angle should be from 10 degrees to 15 degrees, some mechanics claiming best results with 20 degrees. The latter, however, seems greater than there is any necessity for on ordinary work.

Kind of Steel Used for Die Work.

For most work the stock used in making punches and dies should be a good quality of tool steel. A die that has cost from 5 dollars to 100 dollars for labor is as liable to crack when hardening as though

the same steel had been made into any other form of tool; and in fact its shape and irregular thickness of stock at various points, together with numerous sharp corners that are liable to be present, make a tool that requires extreme care in handling when hardening. A good grade of tool steel, free from harmful impurities, is less liable to crack than an inferior grade, and the slight difference in cost is offset many times by the cost of labor in the die construction. This does not necessarily mean that a *high-priced* steel must be used for this class of work; simply a *good* quality of steel, low in percentage of those impurities which cause trouble when the steel is hardened. When we speak of good, reliable steels, we do not necessarily mean high-priced steel.

If best results are desired when hardening, the steel should be annealed after the outer surface of the piece has been removed and the opening blocked out somewhere near to shape.

In all shop operations true economy should always be practiced, and many times this may be done by a saving of tool steel. If a die is

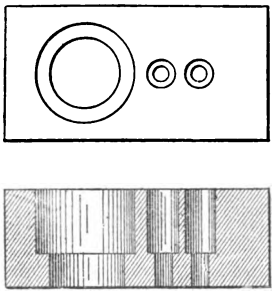

Fig. 5. Cast Iron Body Die, used with Tool Steel Bushings

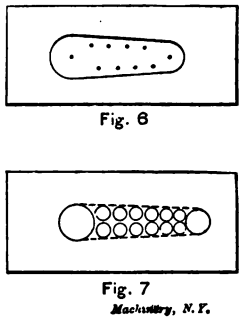

Fig. 6

Fig. 7

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Figs. 6 and 7. Method of Removing the Stock in a Solid Die.

like Fig. 5, a saving may be effected by making the body of cast iron and inserting bushings of tool steel; and if we wish at any time to make a new die, we simply make the bushings, and if ordinary care is taken the holes will be concentric and consequently the proper distance apart, so there will be no necessity of altering the location of the punches, as might be the case if a die made of a solid piece was hardened.

General Principles of Die Making.

When a number of dies are to be made to fit the same holder, they may be planed to size in the bar and then cut apart by means of the cold-sawing machine. It will be necessary to plane again the side of dies that must fit a shoe of the style shown in Fig. 2, as one end must be wider than the other. This may be effected very readily by having a strip of cast iron planed to the proper taper to place the die on when planing or milling. The face of the die must be smooth in order that the outline traced on it may closely correspond to the templet. If the surface is a succession of ridges, the scriber will not closely

follow the edges of the pattern, and the figure traced will be larger than desired. After the face has been made smooth by planing, grinding or filing, the surface may be coated with blue vitriol solution, or it may be heated until it assumes a distinct straw or blue color, and the outline of the piece to be punched laid out.

If the die is what is known as a solid die, that is, made from one piece of stock, it may be laid off and prick-punched as in Fig. 6, after which holes may be drilled, leaving the face of the die as in Fig. 7,

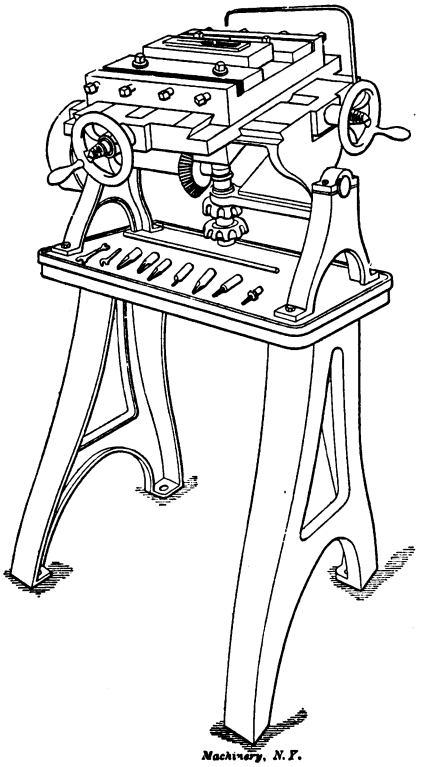


Fig. 8. Die Milling Machine.

after which the core may be removed. When drilling for the opening, first drill any portions which are to be left circular or semi-circular in shape. These are then reamed from the opposite side with a taper reamer that will give the desired amount of clearance. When drilling to remove the core mentioned, some tool-makers use drills of sizes that break into the next hole. After drilling all way round, the core drops out of its own accord. If this method is adopted, best results follow the use of the straight-fluted drill, Fig. 9. Others drill with drills of the size of the pilot of a counterbore, and after drilling all the holes, the counterbore is run through. Of course, it is understood

that in laying off for the holes, they are located so that the counterbore breaks into the next hole. A third method consists of laying off and drilling holes so there is a little stock between the holes after drilling, which is broken out by means of a drift driven in from each side until the cuts meet. In this way the stock is cut away and the core removed.

After taking out the core, the die may be placed in a die milling machine, or a die sinking machine, and by the use of a tapered milling cutter the stock may be removed and the desired angle of clearance given the walls of the hole. The angle of clearance necessary for best results cannot be arbitrarily stated, but varies according to the character of the work to be done with the die. In the absence of either of the milling machines mentioned, a universal or a hand miller may be used. There are various slotting devices which may be attached to universal milling machines which are used advantageously on work

Fig. 9

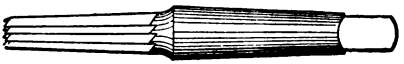


Fig. 10

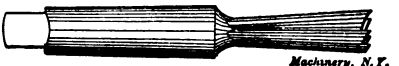


Fig. 11

Figs. 9, 10 and 11. Tools used in Die Making Machines.

of this character. During the past few years several vertical filing machines have been placed on the market which are recommended highly for the purpose of working the openings of dies to shape. If a die milling machine, Fig. 8, is used, the form of taper milling cutter shown in Fig. 10 is employed. As the milling cutter is driven by a spindle beneath the die, the cutting portion extending up through the opening, with the face of the die uppermost, the small part of the cutting portion should be at the end of the cutter. If a die-sinking machine, Fig. 12, is used, a cutter like Fig. 11 is employed. After working the opening to shape and size as nearly as possible with the milling cutter, it may be finished by filing.

Clearance.

When finishing the opening to shape and size it is necessary to get the desired clearance and to have the walls of the opening straight, as at *a a* in Fig. 13, rather than rounding as represented at *a a* in Fig. 14. The amount of clearance differs for various work and ranges from one-quarter to three degrees. The greater amount is seldom given unless it is necessary that the blank fall from the die each time one is punched. Another instance where it is desirable to give excessive clearance is where a punch with a crowning face, as in Fig. 15, is used for punching stiff stock.

When a milling machine with a slotting attachment, Fig. 17, is used, sharp corners may be cut to the line, as may certain irregular sur-

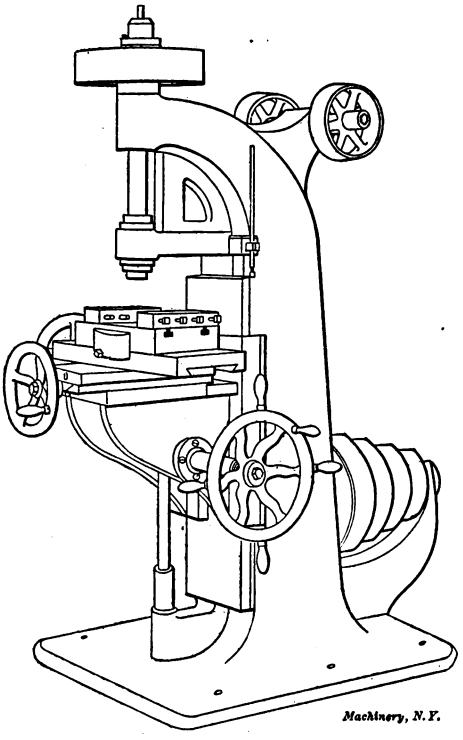


Fig. 12. Die Sinking Machine.

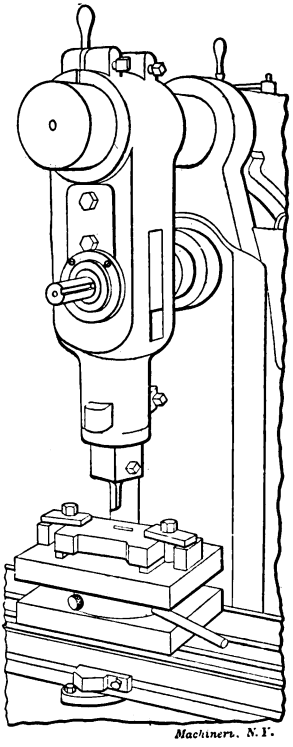


Fig. 17. Die Slotting Attachment for Milling Machine.

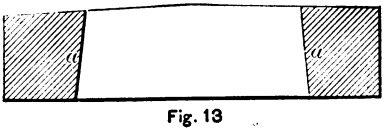


Fig. 13

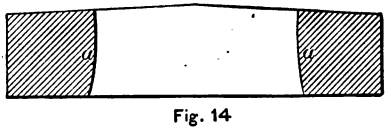


Fig. 14

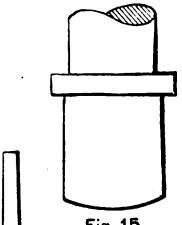
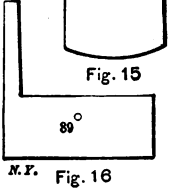


Fig. 15



Machinery N.Y. Fig. 16

Figs. 13 and 14. Correct and Incorrect Relief. Fig. 15. Punch Crowned for Stiff Stock. Fig. 16. Templet for Gaging Relief.

faces which could not be shaped with milling cutters. Of course, it would be necessary to have cutting tools of the proper shape to

machine the forms mentioned, the advisability of making which would depend on whether it would be cheaper to make the necessary tools and to do the machining, or file to the desired shape. A fixture known as a die shaper, whose action resembles the slotting device described above, is made to attach to a milling machine and works the same as the other attachment.

In order to gage the angle of clearance it is advisable to have angle gages. Several of these may be made and kept in the tool chest and should be of the more common angles used. They may be of the form shown in Fig. 16, with the angle stamped on the heavier portion.

Shear of Punches and Dies.

The cutting faces of dies are given *shear* for the same reason that the teeth of milling machine cutters are cut helical or spiral. The shear makes it possible to cut the blank from the sheet with less expenditure of power; it also reduces the strain on the die and punch. While it is customary to shear the face of the die when possible, there are instances when it is advisable to leave the face of the die

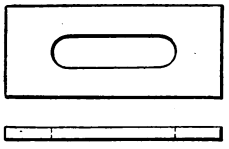


Fig. 18. A Piece of Work for which the Punch Should be Provided with Shear.

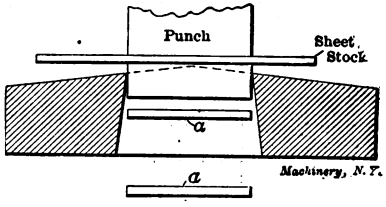


Fig. 19. A Case where the Shear Should be on the Die.

flat and shear the punch. The shear is given to the *punch* when the stock around the hole is the desired product and the stock removed is scrap, as in Fig. 18. The face of die is sheared when the portion pressed through the die is the product, as at *a a* in Fig. 19, which also illustrates the shear of the die.

The amount of shear necessary to give a die to obtain best results depends a great deal on the thickness of the stock to be punched, and also on the length of the piece to be removed, and on the power of the press. The shear of a die usually commences at the center and extends toward each end, as in Fig. 19, the punch being left flat on its face. When the punch descends, the cut commences at the highest point of the die, which is in the center, and continues toward each end. The portion at the center will have been removed from the stock before the cut has progressed very far toward the ends, and in this manner the cut is distributed over the length of the piece, reducing the strain on the press and tools.

The diemaker, if he works to drawings furnished him by the draftsman, makes the thickness of die and length of punch to correspond with dimensions. However, it is customary in shops where few dies

are made and no draftsman is employed, to give the diemaker or toolmaker an idea of the shape and dimensions wanted, or possibly a templet, and he is required to go ahead and "work out his own solution." In such cases the workman must first find the dimensions of the press to be used, the distance from the bed to the ram, the length of stroke of the ram, the amount the ram may be adjusted, the thickness of the bolster, and particulars about any shoes that are to be used. These things should be carefully set down and kept where the workman may have access to them at any time. If there are several presses, each should be marked and the dimensions of each carefully recorded, according to the work of the individual machine. If this precaution is followed and the dimensions taken into consideration when machining the die and punch, there need be none of the trouble sometimes experienced, such as a die too thick or a punch too long, or the reverse, for the press in which they are to be used.

Stripping the Stock.

When articles are punched from sheet stock, or in fact from any stock where the scrap is around the punch, the stock will be carried

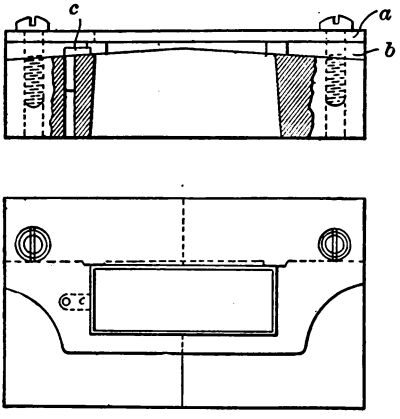


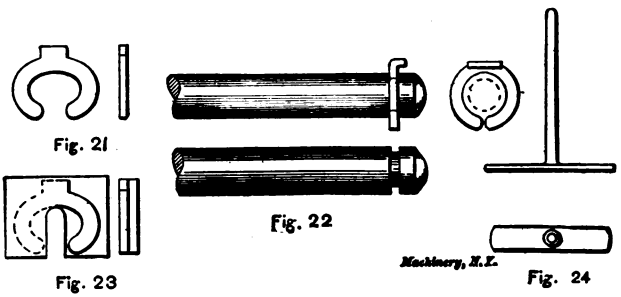
Fig. 20. Example of Stripping Plate.

upward when the punch ascends, unless some device is furnished to prevent its doing so. Fig. 20 shows an arrangement *a* called a stripper, or stripping plate, the opening in this being a trifle larger than the punch. The stripper plate must be securely fastened to the die, or the die holder, and must be stiff enough to prevent its springing when in use. Between the stripper and the die (at *b*) is a guide against which the stock being operated on rests, and which determines the amount of scrap at the back edge of the sheet. This guide is made of a thickness that insures the space between the die and stripper being somewhat greater than the thickness of the stock used; in fact, the space must be sufficient to allow the stock to move along

easily even when the surface is made somewhat irregular by the operation of punching. At *c* is a guide pin or stop against which the stock is placed to determine the endwise setting.

Templets.

When dies are made for producing pieces that must be of a given size and shape it is necessary to have a piece of the same shape and size to work to; this is called a templet. At times it requires a considerable degree of skill to make a templet that will answer for the work in hand. As an example, the templet shown in Fig. 21 may be referred to. After blanking and turning the ear at the top of the piece to be made, it was to be closed on a groove in an axle, as shown in Fig. 22. After closing, the outside of the washer was supposed to run about true. The die was made to the templet and it was found less difficult to make the die than the templet. In this instance it was necessary to make two pieces of the desired shape exactly alike, one of which was closed on the model axle and tested. The points that were not right were located on the one that had not been closed up. Then others were laid out from it, due allowance being made for the im-



Figs. 21 to 24. Example of Templet Making.

perfections of the first. When making, two pieces of stock were placed together and one half was worked to the laying out lines as in Fig. 23. After the other half had been blocked out somewhere near the line, the pieces were reversed and each half that had been blocked out was finished to the finished half, as shown. In this way the ends were exactly alike and the two being machined, or filed together, were, of course, alike. When one was forced down or closed on the axle and was found correct, the other answered for the templet to be used in laying out the die, and afterward to fit the opening, too. While the example related was comparatively simple, it did not appear altogether simple to one not accustomed to that class of work, and it serves to illustrate the idea brought out.

In order that templets may be easily handled, it is customary to attach some form of handle to them, which is sometimes done by drilling and tapping a hole in the templet, and cutting a short thread on a piece of wire which is screwed into the tapped hole. Another common method is to attach a piece of wire by means of a drop of solder, as

shown in Fig. 24. This method is open to the objection that the wire must be removed from the templet when it is used in laying out the punch, as it is necessary, when the templet differs in shape on two edges, to lay opposite sides of the templet against punch and die.

Sectional Dies.

Dies are many times made in two or more sections in order to facilitate the operation of working the opening to shape. In other cases the die, if solid, would be so large as to render it well-nigh impossible to harden it in a shop with only the usual facilities for doing work of this class. And then again if it should go out of shape in hardening, it would be a difficult task to remedy the defect. If made in sections, as shown in Fig. 25, it would be possible to peen or grind to the original shape with little trouble.

A die of the design shown in Fig. 26 may be made sectional because it is much easier and cheaper to make than if solid. The sections

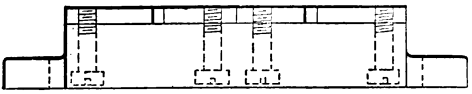


Fig. 25. Sectional Die held by Screws.

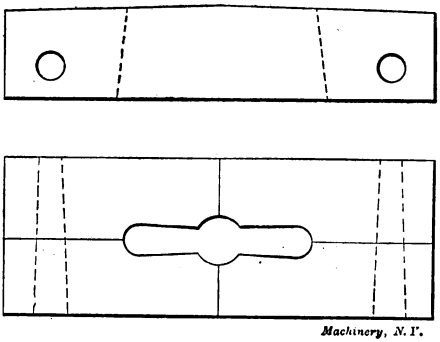


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Fig. 26. Sectional Die Located by Taper Pins.

are held in their proper location by dowel pins. They are held together by the shoe which secures them in the press. If the die is comparatively small, the circular shapes at each end and center are produced by first drilling, and then reaming from the back, with a reamer of the proper angle. The sections may be separated and the balance of the stock removed in a shaper, planer or milling machine. When this stock is removed the die may be held at the proper angle to produce the desired clearance. After machining as close as possible, the surfaces may be finished with a file and scraper.

When the opening has been finished to the templet, the top may be given the proper *shear*. In order to facilitate the operation of grinding when the die is dull, the stock may be removed, as in Fig. 27, leaving about ¼-inch each side of the opening at the narrowest portion.

There are certain forms of dies where it is not feasible to cut away a portion of the top, as shown, but where it can be done it saves much time when grinding.

Correcting Mistakes Made in Dies.

Should the workman, through misunderstanding or carelessness, make the opening too large at any point, he should not attempt to

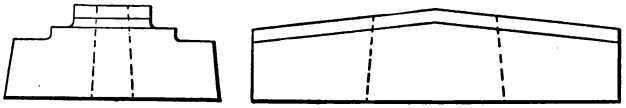

Fig. 27. Method of Cutting Away the Top of Die to Facilitate Grinding.

peen the stock cold, as is sometimes done, for while it is possible to do this and then finish the surfaces in such a manner that it will be scarcely noticeable, the stock directly below where the peening took place will almost surely crack during the life of the die.

Should the mistake referred to occur, heat the die to a forging heat, when the stock may be set in without injury to the steel. When set-

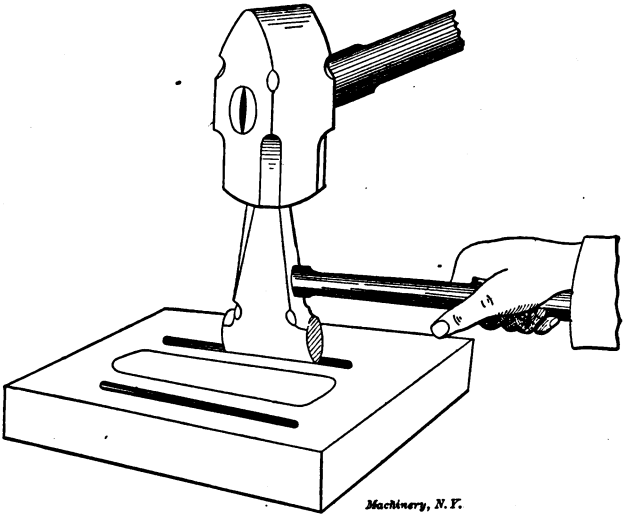

Fig. 28. Closing up a Die which is too Large.

ting in, a blacksmith's fulling tool may be used, this placed on the face of the die and struck with a sledge, as in Fig. 28. If there is objection to disfiguring the top surface of the die, this method can, of course, not be used, but if the top is to be cut away, as shown in Fig. 27, the depression made by the fulling tool would be entirely cut away. It is never good practice to bend, set in, or otherwise alter the form of steel when cold, if it is to be hardened, as such attempts nearly always end in a manner entirely unsatisfactory.

Reworking Worn Dies.

When a die becomes worn so that the opening is too large, or the top edge of the walls of the opening are worn so that the die is "bell muzzled," it may be heated to a forging heat, set in with a fulling tool, or a punch of the desired shape, after which it is reheated to a low red and annealed. After annealing it is reworked to size. This reworking, care and judgment being used, gives excellent results, and effects

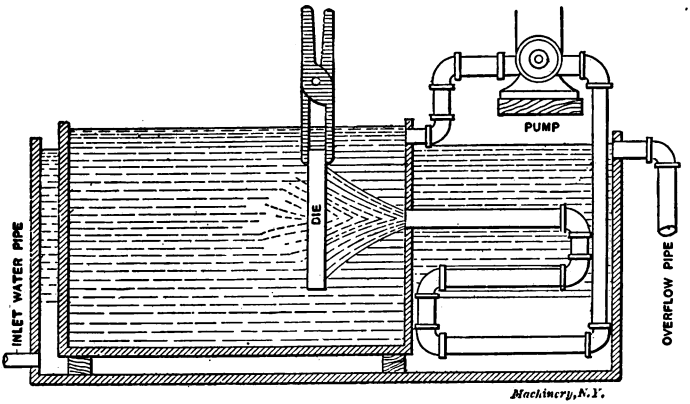

Fig. 29. Arrangement of Oil Cooling Bath.

a considerable saving, as otherwise it would be necessary to make new dies, while the die may be reworked at a fraction of the expense of a new one.

When making a sectional die, it is possible in case the opening is a trifle too large, to work a little stock off the faces that come together, provided the outer edges have not been planed to fit the holder; also, if it is allowable, these surfaces may be cut away the desired amount, and a strip of stock of the proper thickness placed between the die and holder. Considering the liability of a mistake taking place when the beginner is doing work of this kind, it is, generally speaking, advisable to leave the fitting of the die to the holder until the opening has been worked to size.

Hardening Dies.

There is probably no one article the hardener is called on to harden that he dreads any more than a die. If he succeeds in bringing it out of the bath without a crack, he gives the credit to "luck"; and if it cracks, it is almost what he was looking for. This is an unfortunate condition, as there is no need of losing dies in the operation of hardening. Of course, if a piece of imperfect steel is used, it is almost sure to go to pieces in the bath; but if the steel is of the proper quality and in good condition, there need be no trouble when hardening.

When handling work so diversified in character as the class under consideration, the operator should not assume that it is possible to

adopt any set method which is not to be deviated from, as there is no one class of work that calls for a greater exercise of skill and common sense than the proper hardening of punch press dies, unless it be the hardening of drop-forging dies. For most dies of this character, however, and especially for those complicated in form, and which must retain as nearly as possible exact measurements, there is no method that will give the satisfaction derived from the method known as "pack hardening."

Pack Hardening.

When pack hardening such pieces, best results are derived from the use of a bath of raw linseed oil of the type shown in Fig. 29, in which the oil is kept from heating by pumping through a coil of

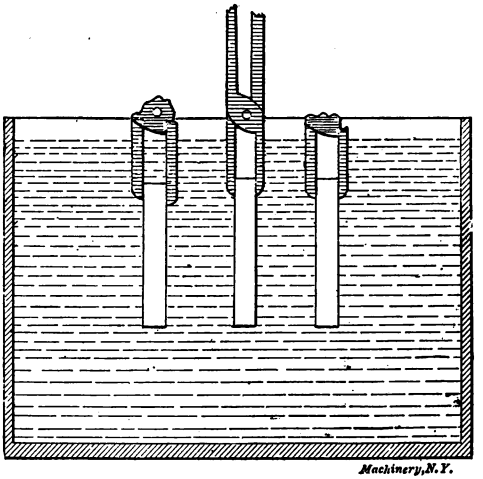

Fig. 30. Dipping the Work in the Bath.

pipe in a tank of water, and then forced into the bath and through the opening as shown. If such a bath is not at hand, good results can be obtained where the oil is not agitated but the die is swung back and forth and moved up and down somewhat in the oil. If many dies are to be hardened this way, however, it is necessary to have a bath of generous proportions, or else several smaller baths, as it would not do to use the oil after it becomes hot, although oil that is heated somewhat will conduct the heat from steel more rapidly than would be supposed, and is better adapted for hardening than if it is extremely cold.

General Directions for Hardening.

The secret of success in hardening dies by the ordinary method consists in getting as nearly as possible a *uniform* heat. To accomplish this the die cannot be heated very rapidly, as the edges and lighter portions would heat more rapidly than the balance of the piece. Unequal contraction, when quenching in the bath, follows

uneven heating, and unequal contraction causes the die to crack. High heats cause cracks in steel. Then, again, high heats render the steel weak, and as a consequence it cannot stand the strain incident to contraction of one portion of the steel when another portion is hard, and consequently rigid and unyielding. Steel is the strongest when hardened at the proper temperature, known as the refining heat.

Cold baths are a source of endless troubles when hardening dies. They will not make the steel any harder than one that is heated to a temperature of 60 or 70 degrees, or even warmer than this, but they will cause the die to spring or crack where the warmer bath would give excellent results. A bath of brine is to be preferred to one of water for this class of work, the brine being heated to the temperature mentioned above.

Have the bath of generous proportions. When the die is properly heated, lower it into the bath as shown in Fig. 30, moving it slowly back and forth to the positions shown, which causes the liquid to circulate through the openings, thus insuring the walls of the opening hardening in a satisfactory manner. Then again, moving back and forth brings both surfaces of the piece in contact with the liquid, causing them to harden uniformly, and preventing an undue amount of "humping," as would be the case if one side hardened more rapidly than the other. The workman must, of course, exercise common sense when doing this class of work. If he were to swing a die containing sharp corners, intricate shapes, and fine projections as rapidly in the bath as it would be safe to do were the opening round or of an oval shape, it might prove disastrous to the die, as such a shape would give off its heat very rapidly, and as a result the fine projections and sharp corners would harden much quicker than the balance of the die; and as they continued to contract, the projections would fly off, or the steel would crack in the corners. To avoid this, have the bath quite warm, move the die slowly, and as soon as the portions desired hard are in the proper condition, remove the die and plunge it in a bath of warm oil, where it may remain until cooled to the temperature of the oil.

Most of the trouble experienced when hardening dies is occasioned by one of two causes—possibly both. The first cause is uneven heating, the second, cold baths.

The Punch.

The method of holding the punch depends on its shape and the style of die, as well as on the holders at hand in the shop. If it can be made in as in Fig. 34, with a shank to fit a holder which enters an opening provided in the lower end of the ram, it will be comparatively simple to make. At other times it will be necessary to attach several punches to a holder, as in Fig. 31. When these punches can be attached to the holder by means of round shanks it will be found a satisfactory method. For many forms of punches, however, this would not answer, it being found necessary to attach them by screws, dowel pins being provided to keep them in position, as in Fig. 32 at *a*. Then, again, it is sometimes thought advisable to use a fixture for hold-

ing the punches, having a dove-tailed slot cut in the face as in Fig. 33, the punches having a tongue which is fitted in the slot. The punches are securely held by means of setscrews. As the opening in the lower end of the ram to receive the punch holder of small presses is ordinarily square, the holder is made of a shape that fits the opening, the hole to receive the punch being round. At times the holder is split

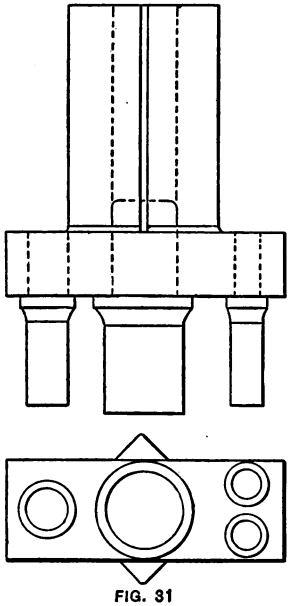

FIG. 31

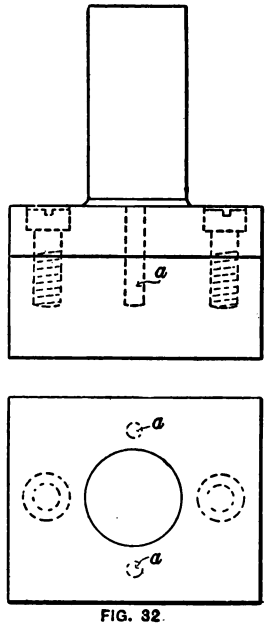

FIG. 32

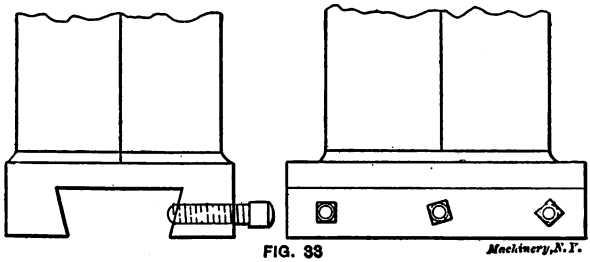

FIG. 33

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Figs. 31, 32 and 33. Various Methods of Holding Punches.

as in Fig. 35. When pressure is applied, the holder is closed onto the shank of the punch, thus holding it securely. At other times the holder is made without splitting, and a setscrew placed in the lower end of the holder, Fig. 36. This setscrew, when screwed against the punch, holds it securely in place.

It is customary to make the die, and harden it, and then make the

punch and fit it to the die. After squaring the end of the punch that is to enter the die, the surface is colored with blue vitriol solution, or by heating it until a distinct brown or blue color is visible, after which the desired shape is marked on the face by scribing. If it is considered advisable to lay out the shape by means of the templet, it may be done; but if the templet is not of the same shape on its two edges, or the ends are different from one another, it will be necessary to place the opposite side against the punch from that placed against the die when marking. However, it is the custom many times to mark the punch from the die. If the die is given shear, it is necessary to mark the punch before the face of the die is sheared. When

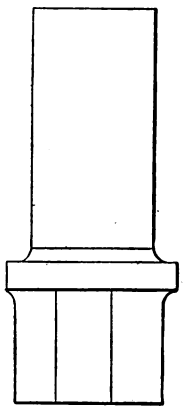

FIG. 34

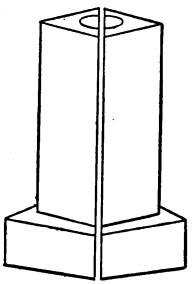

FIG. 35

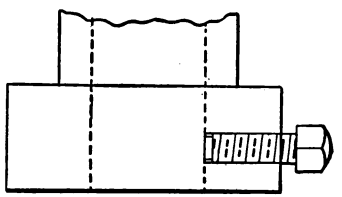

FIG. 36

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Figs. 34, 35 and 36. Punch and Punch Holders.

laying out several punches from a die which has a number of impressions, it is necessary to lay out the punch from the die.

The surplus stock on the punch is removed by filing, chipping, milling or planing, as the case may be, until it is but a trifle larger than the opening in the die. The end is then cornered somewhat so that it enters the opening, and the punch is forced into the die a little way. It is then removed, the stock cut away, and the punch forced in again, this time somewhat further. This method is continued until the punch enters the die the required distance. It is then filed or scraped until the desired fit is obtained. When punch and die are to be used for punching paper, soft metals, or thin stock, the punch must fit nicely. If the stock is thick, or stiff, the punch may be somewhat looser.

For stock ¼ inch thick it is the practice many times to have a 1/32-inch space between the punch and die at all points. The exact amount cannot be stated arbitrarily, it being governed by existing conditions.

There are instances in which it is advisable to make punches somewhat differently from the method described. When the nature of the stock to be punched is such as to cause it to cling to the punch, making the operation of stripping difficult, to the extent that any stripper plate put on the die would be bent, or the end of the punch pulled off during the operation, the punch may be made straight for a distance that allows of grinding several times, then the portion immediately above this may be given a taper. This tapered portion of the punch is intended to enter the stock, *but not the die.* Its action is to increase the size of the opening somewhat, thus making the operation of stripping possible without endangering either the stripper or the punch.

Advisability of Hardening Punches.

There are various opinions among practical men as to the advisability of hardening punches. For most jobs it is the custom to do so, though there are some mechanics who consider it advisable to harden them and others who do not. There are instances where punches work well either way, and in such cases it is, of course, a matter of opinion. If good results follow the use of a soft punch it may be used, and as the punch wears, it is upset and sheared into the die.

There are times when a soft die and hardened punch work well, and times when a hardened die and soft punch give good results. At other times both punch and die may be left soft. Very large punches and dies for hot trimming of drop forgings are sometimes used, where both are in a soft condition, and they stand up properly. The shape of these, together with the size, often make it impracticable to harden them. It would not be advisable to state that such and such dies or punches should be hard or soft; it must be determined by the circumstances under which they are to be used, and the decision is a matter of experience on that particular work.

Directions for Hardening Punches.

If punches are to be hardened—and it is generally considered best—they should be very carefully heated. It must be borne in mind that punches are subjected to great strain, consequently they should be heated uniformly, and to as low a temperature as will give desired results, thus making them as strong as possible. Heat slowly to avoid *overheating* the corners, as these are subjected to the greatest strain. The distance we should harden a punch depends on the shape and size, and the use to which it is to be put. If it is a piercing punch of the form shown in Fig. 37, it should be hardened the entire length of the portion marked *a* to avoid any tendency to bend or upset when in use. If it is of a form that insures sufficient strength to resist any tendency to upset when in use, as in the punch illustrated in Fig. 38, then it need not be hardened its entire length.

Pack hardening makes an admirable method for hardening punches for most work, but for piercing punches of the type shown in Fig. 37 it is not advocated, as the whole structure of steel should be as nearly as possible alike. Such punches should be heated in a muffle furnace, or in a tube in the open fire, turning occasionally to insure uniform results, for not only can we heat a piece more uniformly if it is turned several times while heating, but a fact not generally known is that a cylindrical piece of steel heated in an ordinary fire without turning

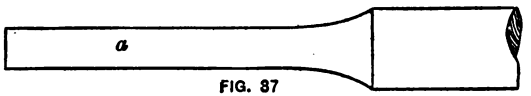

FIG. 37

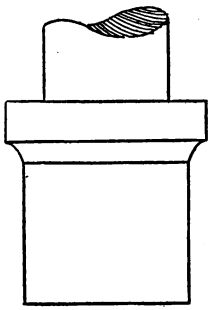

FIG. 38

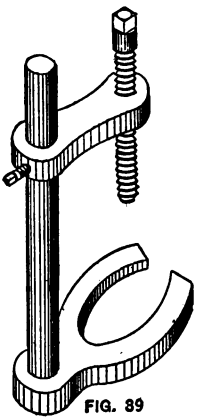

FIG. 39

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Figs. 37 and 38. Shapes Requiring Different Treatment in Hardening.
Fig. 39. Clamp Used When Scribing Die Outline on Punch.

while heating will many times show softness on the side that was uppermost in the fire, no matter what care was taken when heating and dipping. If it is reheated with the opposite side uppermost, *that* will be found soft if tested after hardening, while the side that was soft before will be *hard*. The smaller the punch the more attention should be given to the condition of the bath. Luke warm brine is the best. Work the punch up and down and around well in the bath.

Tempering Punches.

It is the custom of many mechanics to draw the temper of punches of the description shown in Fig. 37, to a full straw on the cutting end, but to have the temper lower further up the punch. Better results follow, however, if the punch is left of a uniform hardness its entire length of slender portion, as it is then of a uniform stiffness, and the liability of springing, especially when punching stiff or heavy stock, is reduced to the minimum.

It is generally considered good practice to temper the punch so that it is somewhat softer than the die; then, if from any accident the two

come in contact, the die will in all probability cut the punch without much injury to itself. There are exceptions to this, however. In many shops where large numbers of dies which are hardened are used, it is customary to have the one which is the more difficult to make the harder, so it will cut the other if they come in contact with each other.

In order to hold the die and punch blank firmly together when

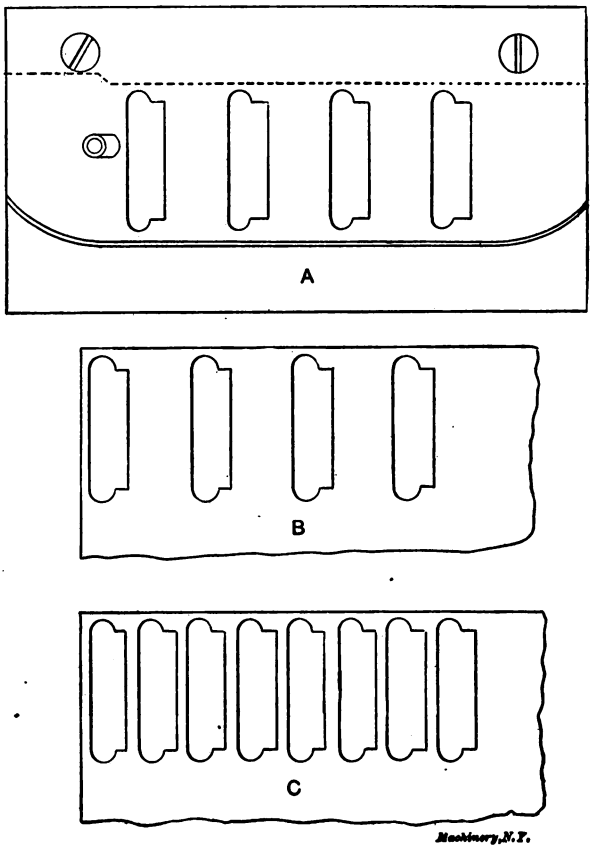


Fig. 40. Multiple Die, and Stock Cut in Same.

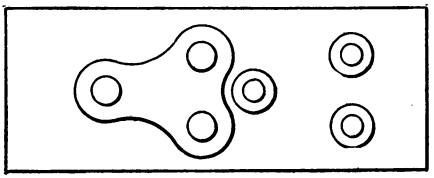
marking the shape on the face of the punch, a very convenient fixture known as a die clamp shown in Fig. 39 is used. When the two are secured by means of this clamp, it is possible to move them around so as to get at the various portions where we wish to scribe.

Multiple Dies.

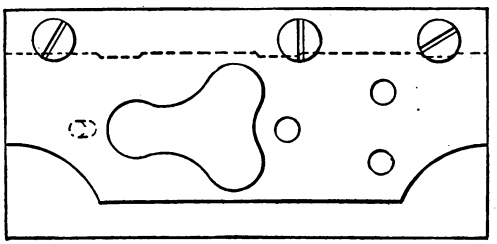
The reduction of the cost of manufacture is often possible by the use of multiple dies, whereby two or more pieces are punched out at a time. In punching perforated steel work it is no uncommon thing

to see punches and dies in use where several hundred punches are working into one die.

If an article, for example, of the form shown in the die in Fig. 40, were to be punched in lots of several thousand, the die should punch a number at a stroke. Such a die and the stock left are shown in Fig. 40, where the die is shown at *A* and the stock after the first punching at *B*. It will be noticed that the distance between the openings is considerable. This is necessary, as it would not be possible to place the openings in the die as close as they should be to econo-



PLAN OF PUNCH



PLAN OF DIE *Machinery, N.Y.*

Figs. 41 and 42. Gang Punch and Die.

mize stock, since there would not be stock enough between to insure the die sufficient strength to stand up when working. For this reason the openings are located as shown. After punching as shown at *B*, the stock is moved along the right distance for the intervening stock to be punched out, as at *C*.

Gang Dies.

If it were desirable to punch a piece like that at *a* in Fig. 43, it would be possible to make a blanking die and punch which would produce the blank of the right size and shape, but without the holes; then, by means of another die, with three punches working into it, we could punch the holes. It is apparent that such a method would be more expensive than one that made it possible to punch the holes and the piece at one passage of the stock across the die. This may be done by the use of a die of the description shown in Figs. 41, 42 and 43. When using this die the stock is placed against the guide and just far enough to the left so that the large punch *b* will trim the end. Then, when placed against the stop or gage pin *c*, bring the guide pins in end of punch *b* in line with the holes punched at the first stroke of the press at the time the end was trimmed.

When the stock is purchased of the proper width for one piece, it is fed through and the scrap thrown aside. At times it is purchased just wide enough for two pieces, in which case one edge is placed against the guide *d* and the stock fed through; after which it is turned over and fed through with the opposite edge against the guide, thus using all the stock except such portion as necessarily becomes scrap.

However, if the stock is purchased in the commercial sheet, it is necessary to trim the edges every time a row is punched along each. If no power shears are located handy to the press this may prove to be a more costly operation than the punching, and no matter how conveniently such a shear may be located, the operation adds a con-

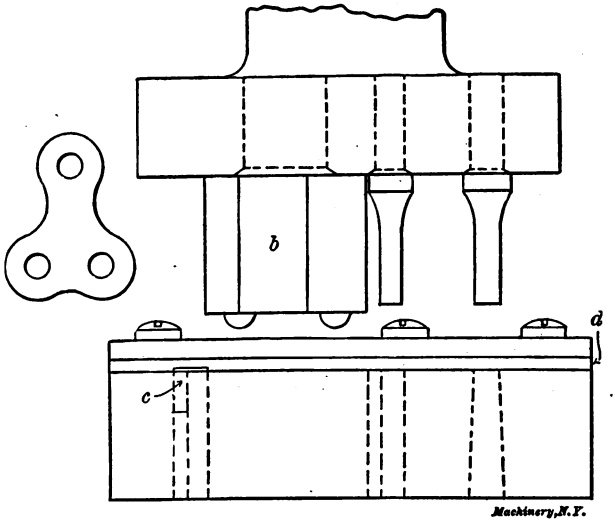


Fig. 43, Elevation of Gang Punch and Die shown in Plan in Figs. 41 and 42.

siderable cost to the product. To avoid this trouble and expense another punch and opening in the die may be added. The object of this punch is to remove the scrap between the openings in this sheet and also trim the edge of the sheet, thus making it straight and in condition to bear against the guide on the die. The die and punch with the addition mentioned are shown in Fig. 44. When using a trimming punch as described above, it is necessary to use a stop of the description shown at *b*. The end of the scrap striking this governs the location of the stock, and when the punch descends the scrap is cut away.

When making dies of this class it is necessary to have the blanking die *a* the longer in order that the locating pins on the end may engage in the holes in the stock and locate it right before the other punches reach the stock. It is also necessary to place the stop, or gage pin, so the stock will go a trifle further than its proper location—say 0.010 inch. Then, when the locating pins engage with the holes, they draw

the stock back to its proper location; whereas if the tool-maker attempted to locate the stop exactly, any dirt or other foreign substance getting between the end of the scrap and the stop would cause trouble.

Bending Dies.

While it is possible, in certain cases, to bend articles during the operation of punching, it is usually necessary to make a separate operation of bending. There are instances where bending fixtures which may be held in a bench vise, or attached to the bench, answer the

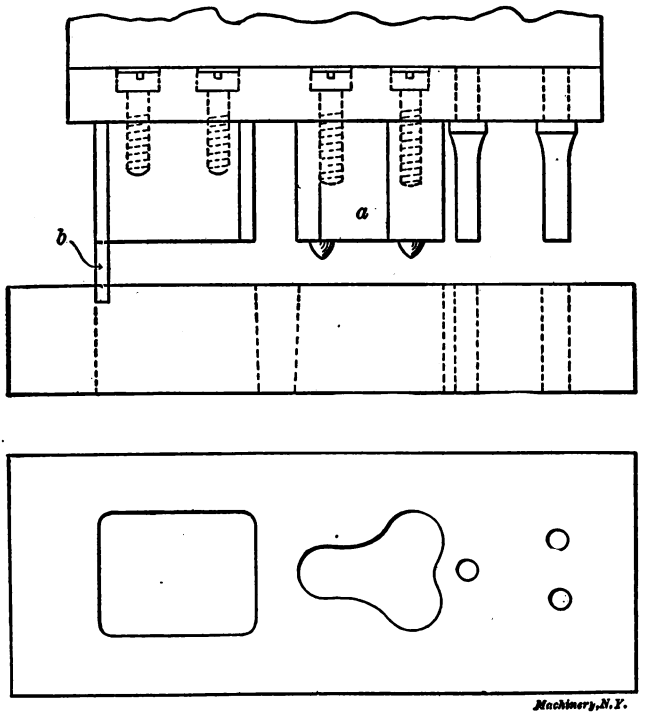


Fig. 44. Gang Punch Arranged to Use Sheet Stock.

purpose as well and allow the work to be done more cheaply than if bending dies were used. But as a rule the die used in a press provides the more satisfactory method, and allows the work to be done at a fraction of the cost.

It is sometimes possible to make the dies so that the various operations can be done in different portions of the same die block, the piece of work being changed from one portion to another in order as the various operations are gone through. At other times it is necessary to make several sets of bending dies, the number depending on the number of operations necessary. When a "batch" of work has been run

through the first die, it is removed from the press and the next in order placed in, so continuing until the work has been brought to the desired shape.

When a comparatively small number of pieces are to be bent to a shape that would require a complicated and consequently costly die in order that the work might be done at one operation, it is sometimes considered advisable to make two dies, which are simple in form and inexpensive to make, to do the work. At times the design of the press is such that a complicated die could not be used; and as a result additional dies of a simpler form, and which can be fitted in the press, must be made.

We will first consider the simpler forms of bending dies. Fig. 45 represents a die used in bending a piece of steel, *A*, to a V-shape, as at B. In the case of a die of this form it is necessary to provide an

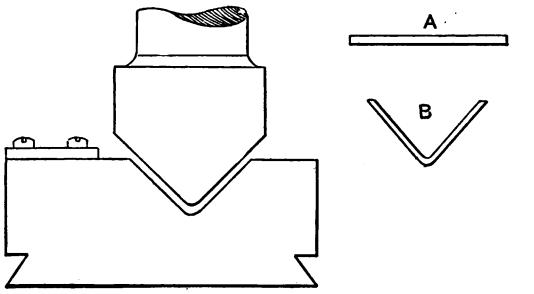


FIG. 45

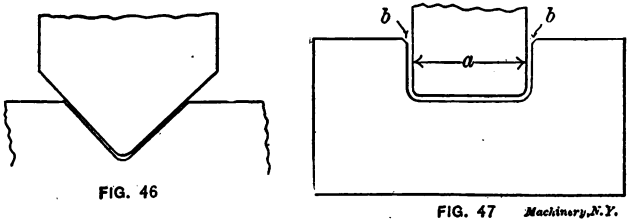


FIG. 46 FIG. 47 *Machinery, N.Y.*

Figs. 45, 46 and 47. Examples of Bending Dies.

impression of the proper shape as shown; this impression, if the die is to be used for bending stiff stock, must be of a more acute angle than if stock having little tendency to spring back when bent to shape be used. Under ordinary circumstances the upper portion or punch would be made of the same angle as the die. It is necessary to provide guides and stops as shown to locate the work properly.

If the stock used in making the pieces is of a high grade and the product is a spring or similar article which must be hardened, it will be found necessary to cut away the die somewhat in the bottom of the impression, making it a little different in shape from the punch, as shown in Fig. 46. This is to prevent crushing or disarranging the grain of the steel to an extent that would cause it to break when in use.

If the die is of the form shown in Fig. 47, it is, of course, necessary to make the length *a* of the punch shorter than the distance across the opening of the die. It must be somewhat shorter on each end than the thickness of the stock being worked. If possible, the upper corners *b b* of the die should be rounded somewhat, as the stock bends so much easier and with less danger of mutilating the surface than when the corners are sharp. When bending thin ductile metal the corners need but little rounding. If the stock is thick, or very stiff, a greater amount of rounding is needed.

While the form of bending die in Fig. 45 answers for ordinary work, there are jobs where such a die would not insure a degree of accuracy that would answer the purpose, and it will be found necessary to make one similar to Fig. 48, where a riser or pad *a* is provided, as shown.

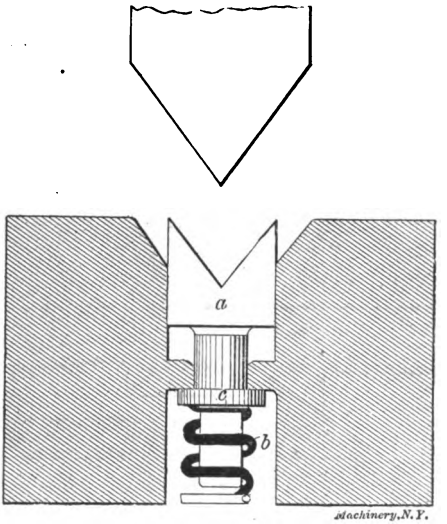


Fig. 48. Bending Die for Accurate Work.

This is forced upward by the spring *b* and is gaged as to height by means of the washer *c* bearing against a shoulder, as shown. It will be observed that the spring gets its bearing against the washer, which in turn bears against the shoulder of the riser as mentioned before. When making this die, the hole is drilled and reamed and the groove milled or planed for the riser, which is put in place sufficiently tight to hold it while the V groove is cut, after which it may be relieved until it works freely. The spring *b* gets its lower bearing on the die holder. If it is considered advisable, a screw may be provided for the spring to rest on. By adjusting this screw, any desired tension may be given the spring, although, generally speaking, this is not necessary.

When bending articles of certain shapes it is necessary to design the tools so that certain portions of the piece will be bent before other portions. Should we attempt to make the tools solid and do the work

at one stroke of the press, the piece of stock would be held rigidly at certain points and it would be necessary to stretch the stock in order to make it conform to other portions of the die. In the case of articles made from soft stock, this might be accomplished, but the stock would be thinner and narrower where it stretched. However, as a rule it is not advisable to do this, and dies are constructed to do away with this trouble.

Fig. 49 represents a die, the upper part of which has the portion *a* so constructed that it engages the stock first. After forcing it down into the impression in the lower portion, part *a* recedes into the slot

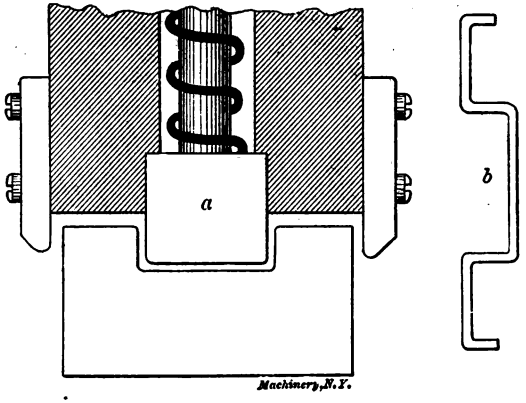


Fig. 49. A Case of Progressive Bending Die.

provided for it. The coil spring shown is sufficiently strong to overcome the resistance of the stock until it strikes the bottom of impression. The article is shown bent at *b*.

Compound Bending Die.

Compound bending dies are used very extensively on certain classes of work, especially in making looped wire connections and articles of thin sheet stock. Fig. 50 shows a die used for bending a bow spring. As the punch descends, the stock is bent down into the impression in the lower half and forms the stock to a U-shape. As the end of the punch with the stock comes in contact with the bottom of the impression it is forced into the upper portion, the spring keeping it against the stock, while movable slides—side benders—*b* are pressed in by means of the wedge-shaped pins so as to force the upper ends of the loop against the sides of the punch as shown in Fig. 51, forming the piece as at *B*. When the punch ascends, the finished loop may be drawn off. If the stock used is stiff it will be necessary to make the punch somewhat smaller than the finished size of the spring, as it will open out somewhat when the pressure is removed.

When making looped wire work, a loop may be formed and the wire moved along against a stop; another loop formed, and so on, as in Fig. 52. When forming looped wire work it is customary to make the

punch ball-shaped rather than as shown in Fig. 50. The ball answers as well on wire work and allows of the easy removal of the loop. It is sometimes desirable to close the upper end of an article nearly together, and if the stock used is extremely stiff, as bow springs made from a grade of tool or spring steel, it may be necessary to heat the

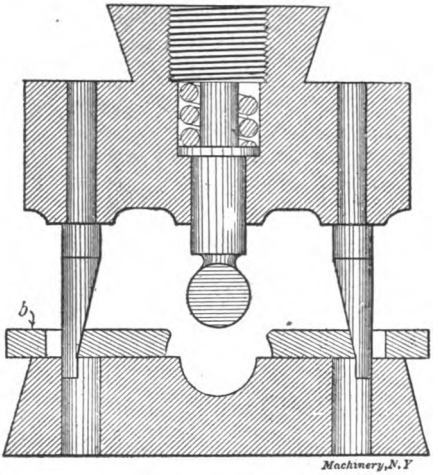


Fig. 50. Die for Bending Bow Springs.

bow, which has previously been bent, red hot, and finish bend it by a special process. In the case of articles made from a mild grade of stock the whole bending process may be accomplished in one operation by substituting a mandrel, as shown in Fig. 53, for the cylindrical portion of the punch.

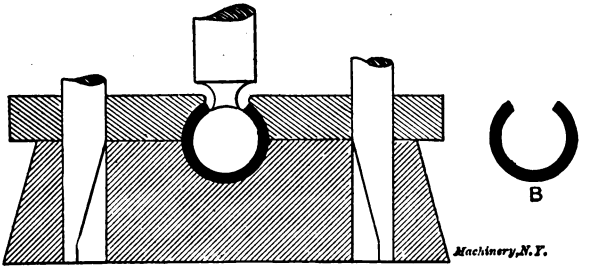


Fig. 51. Action of Die in Fig. 50.

A great variety of work may be done by modifications of the forms of bending shown. Where but a *few* pieces are to be bent it is not advisable to go to the expense of costly bending dies; but when the work is done in great quantities, they will produce work uniform in shape at a low cost. Blanking and bending dies are made which not only punch the article from the commercial sheet, but bend it to the desired shape at the same operation. As a rule, it is advisable to

blank the article at one operation and bend it at another, but there are certain forms of work where it is possible to do it in a satisfactory manner at one operation and at a cost not exceeding that of the ordi-

Fig. 52. Successive Loops Formed in a Wire.

nary blanking operation. This also effects a saving in the cost of tools, as the special bending die is dispensed with.

Fig. 54 represents a punch and die used in punching the shoe *a* to the proper shape shown, while Fig. 55 is one used for producing

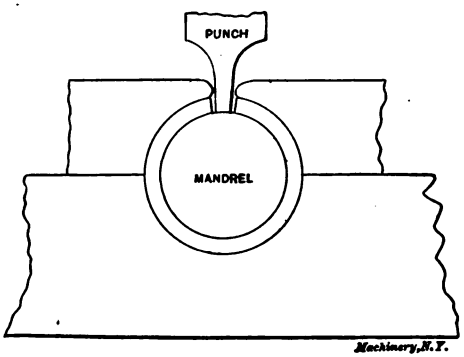


Fig. 53. Forming a Bow Spring with Ends which nearly meet.

the tension washer shown. Gun and other irregular shaped springs are many times punched to form by this style of die, although, when stock suitable for use in making springs is employed, it will be found necessary to make the face of the punch somewhat different in shape from

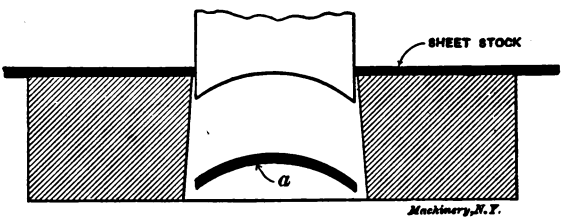


Fig. 54. Punching and Bending at One Operation.

that desired, as the piece will straighten out more or less after it is punched.

If it is desired to curl a form on a piece of work, making a loop as in Fig. 56, it is accomplished by various methods, sometimes by a modification of the die in Fig. 51. A die of the description shown in Fig. 57 is used with excellent results. In making this die, the blank *a* is first machined to size. The hole *b* is drilled and reamed to size,

and polished to produce very smoooth walls. This may be accomplished by using a round revolving lap of the right size. The slot is then milled as shown. If the die is not intended for permanent use and the stock is comparatively soft or easily bent, it need not be hard-

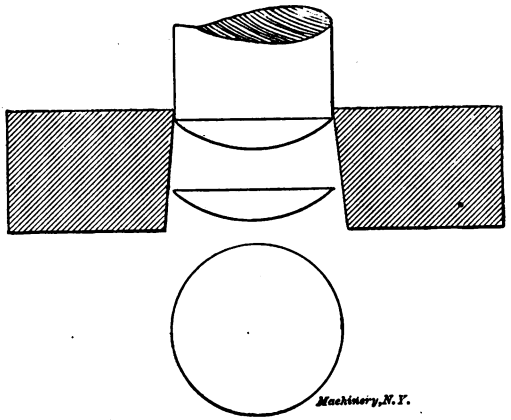
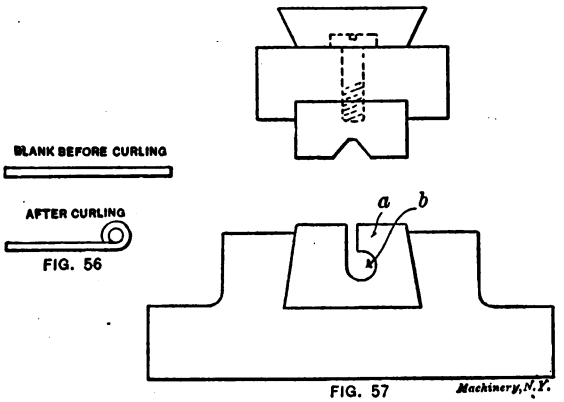


Fig. 55. Making a Tension Washer.

ened. If, however, it is to be used right along, it must be hardened. This is best accomplished by pack hardening, being sure that the heat is low. As in the use of this method the die is quenched in oil, there is little or no danger of its going out of shape. It is then drawn



Figs. 56 and 57. A Curling Die and Its Work.

to a full straw color. The punch is made with a V-shaped impression in its face, as shown. This may be flat in the bottom, as indicated, or left sharp, as desired.

It is possible with presses and tools adapted to the work to form pieces to shapes that to one not familiar with this class of work would seem well nigh impossible.

CHAPTER II.

SUGGESTIONS FOR THE MAKING AND USE OF DIES.

In the phenomenally rapid progress made during the last decade in the press working of sheet metals by the introduction of compound, combination, sub-press, and gang dies, automatic roller and dial feeds, the simpler operations on the power press, instead of becoming subject to similar improvement, have been sadly neglected. It is therefore not out of place to refer, shortly, to the basic elements of the art of using and making dies. Although the following discussion originally was intended to apply to one particular line of presses, the suggestions brought forward may be applied with slight modifications to any make of upright power press on the market to-day.

It is not so generally known as it should be that the inclining of a press adds materially to its productive capacity. This advantage is almost doubled when the same belt may be used in both positions, permitting the change to be readily made without undue loss of time. Many users make it a rule to incline the press on all operations except "push through" jobs, that is, on all work which does not drop through the bed of the press. It is then simply necessary to feed the work to the dies, allowing it to drop out by gravity. To permit the use of the same belt for both positions, the press should be so placed on the floor that the center of the shaft when in its inclined position is the same distance from the line shaft as it is when the press is upright.

While there are many diemakers who advocate the use of a separate cast iron bolster for each die, it is advantageous to use bolsters made of cast steel, which are largely used by Western shops. There are two made for each press, one for cutting dies and one for bending and forming dies, the construction of compound and combination dies remaining unchanged. By this system the separate dies are interchangeable on any press; they occupy less space on the shelves of the tool-room, and inasmuch as all strippers and gages are fastened directly to the die instead of to the bolster, they never become lost when changing from one job to another. The desirability of using standard hexagon head cap screws to hold down strippers, gages, etc., should be impressed upon diemakers. The strippers on any die may then be removed to facilitate correct setting of the die, and then replaced in position—something impossible on slotted head screws except by using an angle screw-driver.

There is little room for improvement in the cast iron punchholder. One might suggest, however, the use of solid piercing punches in place of the drill-rod surrounded by a soft steel sleeve riveted to a punch-pad. Wherever possible, it is advisable to do away with the old-fashioned soft steel punch sleeve, and to let the punches into their holders

either by turning a round shank on them, or dove-tailing them into the cast iron holder in the same manner as the die.

In planing up the die-blank it is well to remember to take a very slight cut from the bottom and a cut about twice as deep from the top.

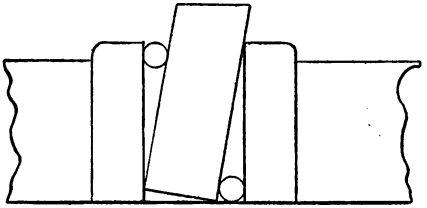


Fig. 58.

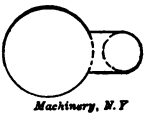


Fig. 59.

This removes the decarbonized surface from the cutting face where it needs most to be done, but leaves it on the bottom where the die may remain soft. Where there is a scarcity of 10-degree parallels, two pieces of drill-rod between the jaws of the vise may be arranged to

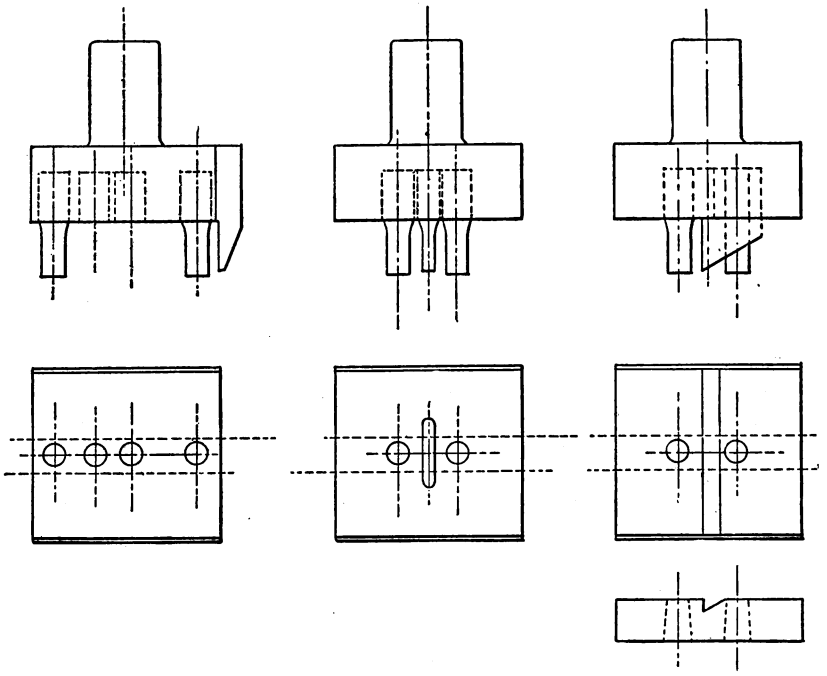


Fig. 60 Fig. 61. Fig. 62.
Steps in the Evolution of Press Tools for Copper Connectors shown in Fig. 65.

give the correct angle, as shown in Fig. 58. Quarter-inch drill-rod is the size to use when the jaws are 1 9/16 inch high. Where intricate shapes must be drilled out with small drills, the holes may be laid out a trifle close together, and the shank of an old drill of the same size

pushed into the first hole drilled. This will prevent the drill from running too far into the previously drilled hole, and by proceeding in this manner all around the outline, the core to be removed will drop out without the use of chisel or drift. The amount of draft on some blanking dies which are combinations of drilled holes, as, for instance, the shape in Fig. 59, may be infallibly indicated by reaming these holes from the back of the die as though they were simple piercing dies. Where extreme accuracy is essential, or a die is too large to be made of a single forging, the use of sectional dies becomes imperative. While the first cost of a well-made die of this kind is higher than that of a solid die, still the ease of repair and uniformity of production of this type of die make it advantageous in the long run.

The dies shown in the illustrations serve to emphasize the main features of this discussion. Fig. 60 shows a die as originally made for the three copper connectors shown in Fig. 65. It is a plain cutting-off die, having the different holes placed in the die at the proper center distances apart. By means of a suitable adjustable gage and by placing one of the piercing punches in its proper position in the punch-holder, the three different sizes of connectors shown in Fig. 65

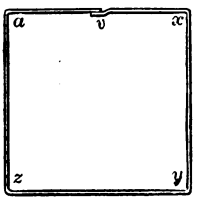


Fig. 63.

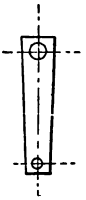


Fig. 64.

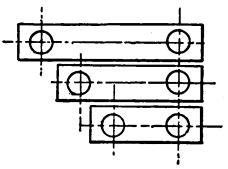


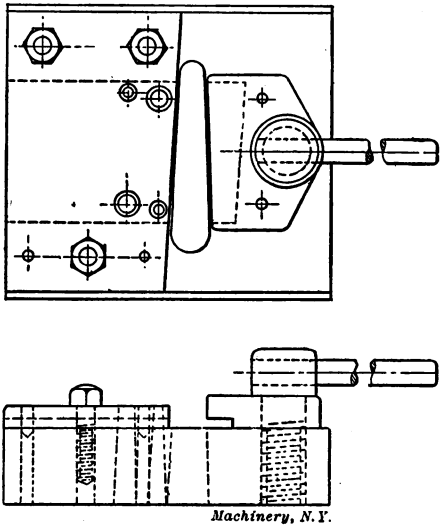
Fig. 65.

may be produced. However, during the process of improvement of the device on which these connectors were used, it became necessary to change the center distances between the holes and also to produce three longer ones. The die shown in Fig. 61 was at first considered adequate, but, on account of the quantity required, the scrap produced by the cutting punch was considered objectionable. Leaving the piercing punches in the same position, the shape of the cutting-off punch was changed, as shown in Fig. 62, and a corresponding V groove planed in the die. In connection with stripper and gage (not shown) this die allows the production of an indefinite number of connectors of different center distances.

The die shown in Fig. 66 impresses the fact that the slitting shear is a valuable auxiliary to any press. The metal for the production of the copper segment ⅛ inch thick, shown in Fig. 64, ordinarily would be cut a little wider than the length of the blank so as to allow the punch to cut all around. But in all cases where at least two sides of a blank are parallel, the stock may be cut the exact width of the parallel portion of the blank in the slitting shear, and then the pieces may be punched and cut off two at each stroke of the press, as shown in the die in Fig. 67. There is one inherent drawback to this form of die,

and that is the tendency of the punch to lift up the end blank while cutting it off and produce a badly beveled edge. But if this portion of the strip is securely held down by the clamping device on the die as shown, the punch will have the same effect on both sides of the blank, cutting it off squarely. The gage and stripper held down by the cap-screws can be made a better fit on the stock than ordinarily, because it is not necessary to lift it up past a stop pin fastened to the die to enable the operator to feed the strip. By inclining the press, allowing one blank to slide out when released by the clamp, and letting the punched one drop through, two complete blanks are produced at each stroke of the press, with almost no scrap.

The extension punch and die in Fig. 67 is quite useful on work which is commonly beyond the scope of the press, such as the sheet



Machinery, N.Y.

Fig. 63. Die for Punching without Waste the Pieces shown in Fig. 64.

iron box shown in Fig. 63. This forms the sides of a slate-bottomed switch cabinet used on the old Manhattan Railway cars when they were equipped with electricity. The operations on this box included the bending of the 2 by ⅛ inch strap iron in four places, forming the lap joint, and riveting same. The cut shows the punch and die (without necessary stops and gages) in position for bending the corners. The front clamping plate is removed from the ram and a cast steel extension bolted in its place with the same bolts. The large hook bolt extending into the hole in the ram and drawn up by the nut outside, is required to support the extension during the strain of bending. To allow the stock to clear the front of the press when bent into shape, the distance *A* in Fig. 67 should be a little more than half the width of the strap iron to be bent, and to avoid fouling the flywheel, corner *x* in Fig. 63 should be the first one bent after the lap

has been formed, and then, in rotation, corners *y*, *z* and *a*. When running the press at its accustomed speed on this job the ends of the bent piece moved rather too fast for comfort, and it was therefore necessary to cut down the speed of the flywheel by inserting resistance in the armature circuit of the motor which drove the line shaft to which three of these presses were belted.*

Method of Locating Stock in Dies.

When a job will not warrant the expense of a sub-die, the device shown in Fig. 68 will help wonderfully toward producing accurate punchings. To simplify the explanation, the die shown is to cut washers, the holes being eccentric with the outside. The die is laid out the same as any double die, but the stop pin *G* is added, and as will be noted, the extension *K* does not come out of the die. If, however,

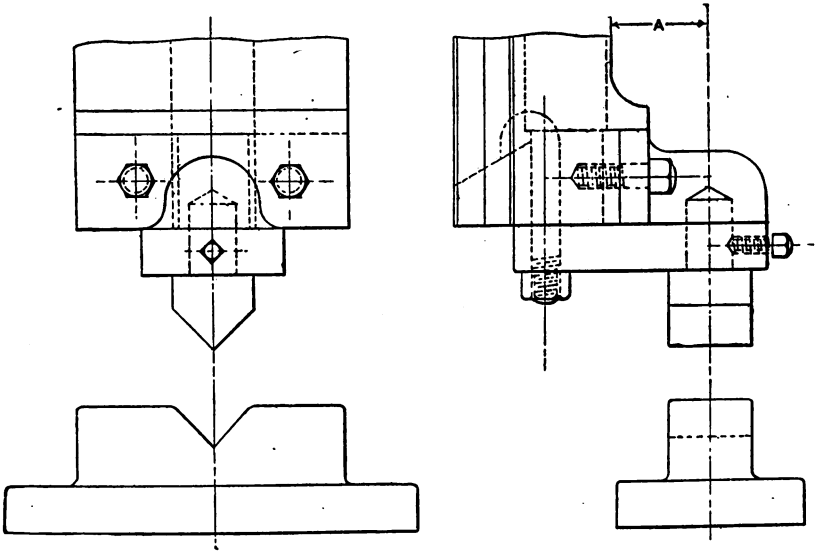


Fig. 67. Die for Corner of Sheet Iron Box.

one depends entirely on this stop pin, the result will not be satisfactory, because, when the stock is pulled against the stop pin, the web between the blanked places will bend a trifle, especially if the stock is thin. Therefore the long pins *H* are added, and as these long pilots or traveling dowels are well pointed, and are considerably longer than the punches, they of course enter the holes and force the stock back to its proper location. The pilots fit two holes in the die, and they therefore act as dowels while the punch is cutting. The pilots and the spring butts *L* keep the stock pressed firmly against the gage side of the stripper, and the stock can vary 1/16 inch. With this construction the operator is enabled to keep the press running constantly to the end of the strip. At each stroke the punch *G* cuts out the web and allows

* H. J. Bachmann, July, 1906.

the stock to slide along to the next web, and there is absolutely no possibility of the stock jumping the stop.

As washer or small wheel dies are generally made to cut four or more blanks at one stroke, the following method of transferring the holes to stripper and punch-holder will be of benefit to some mechanics. If the punches are small, it is advisable to make the stripper, say, ½ inch thick, and dowel it with four good-sized pins to the die. The holes through the stripper are bored to fit the punches nicely. This will act as a guide and prevents the punches from shearing. When the stripper is doweled to the die, we lay out the former with buttons or by other methods governed by accuracy demanded, and each hole in

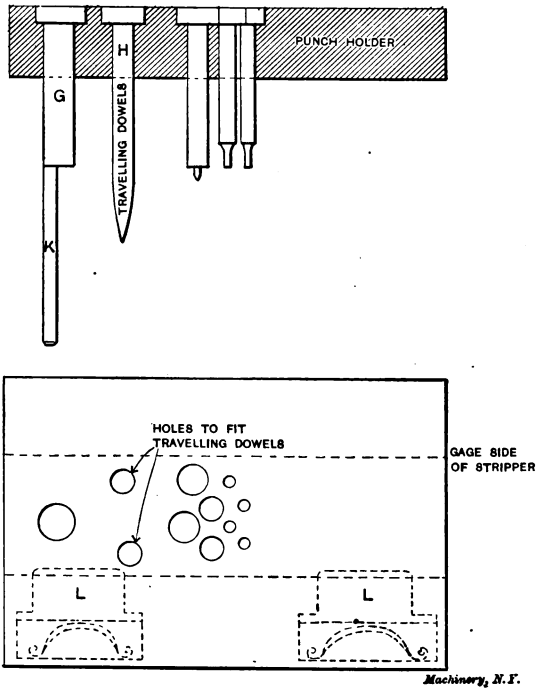


Fig. 68. Punch and Die with Guide Pins.

turn is indicated and bored through the stripper and die. If the holes are so small that they will not readily admit boring to such length, the stripper may be bored and removed and the die then bored. The die must, of course, be fastened in such a manner that the stripper can be removed without loosening the die. If properly doweled, the punch-holder, stripper and die can be bored together, thus insuring perfect alignment of the punches and the die.

Making an Irregular Shaped Die.

Fig. 69 shows a time-saver, as the die can be made easier and better because the parts can be ground to size instead of the die being filed

out. Another advantage is that if the pieces warp in hardening they can be ground into shape again. The pieces *M* are shrunk on the sections, holding them securely together. The holes *N* are drilled for clearance for the emery-wheel when grinding to size. The straps *M* are made a trifle shorter than the die over all, say 1/16 inch to the foot, and are heated red hot in the middle and placed in position while hot, and rapidly chilled. After these pieces are shrunk on, the dowels are transferred into the bolster.

Another good kink when making irregular-shaped punches that are to cut thin stock is to make them of machine steel and case-harden them. Soft steel, case-hardened, does not change its form as much as

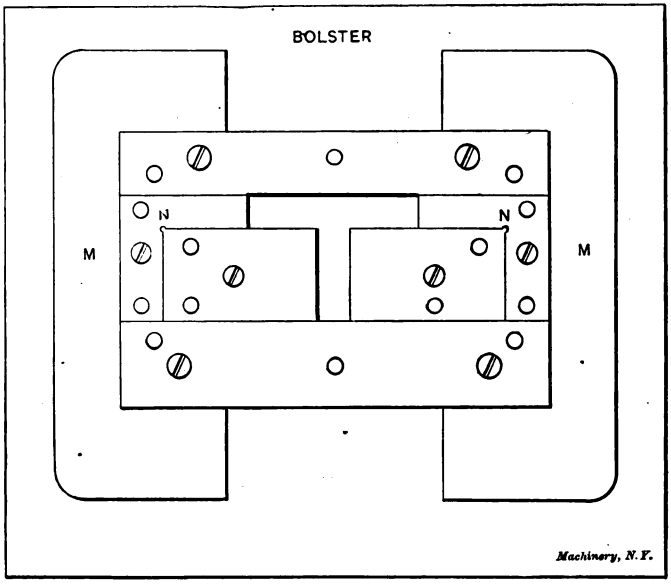
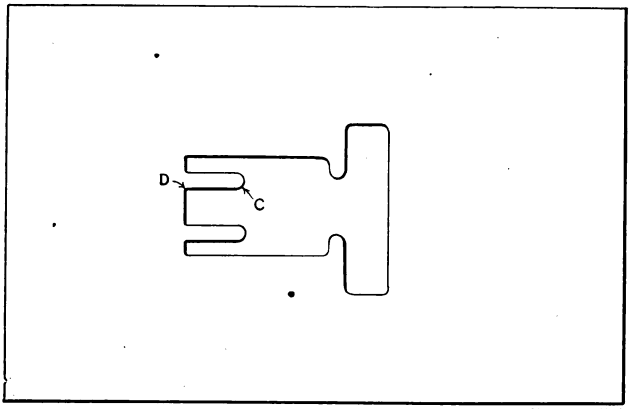


Fig. 69. Example of Built-up Die.

tool steel, and even if the punch does change a trifle, the interior is soft and can be readily forced back to position. The outside being hard, the punch will wear nearly as long as one made from tool steel, for practically the only wear on a punch is when passing through the stock. For thin brass the punch works well when made of tool steel and left soft, and when worn badly the punch can be peened on the face enough to upset, and then sheared into the die. When cutting a heavy blank, it is a good plan to grind the die so that the surface is quite rough, as the high spots then cut a trifle ahead of the low points. This will cause the die to run longer between grindings and is also easier on the press, while with a die that is ground perfectly smooth the entire cutting surfaces of punch and die meet simultaneously, and the entire cutting surface of punch and die are placed under a tremendous strain. By grinding the die slightly lower on each end, thus producing a shearing cut, the die will last longer.

A Kink in Hardening.

What will greatly reduce the chances of springing in hardening of an irregularly shaped punch or die is to thoroughly anneal it after it has been machined nearly to size. This will, of course, not entirely remove chances for accidents, as the prime cause of cracks and distortion of work is to be found in the operators' way of handling the piece to be hardened. An illustration of what takes place when hardening may be given by referring to the die shown in Fig. 70. If we place the die in the fire, the points *C* will heat and expand quicker than the main body of the die, and there must be a sort of a "pushing" effect between the points *C* and the main body of the die. For this reason we heat "slowly and evenly." Now, when we dip the die in the bath, the points *C* immediately become chilled, and, of course, contract while the main body is still red hot. Assuming that the points have become entirely cooled, there must be a line that separates the part



Machinery, N.Y.

Fig. 70. Die of Irregular Shape Subjected to Heavy Strains in Hardening.

that has been cooled off from the red-hot part. It must follow that when the main body begins to contract there is a powerful strain at the line that separates the parts contracting at different times. For this reason the die should be removed when quite warm; this allows the heat to run out into the points and the contraction will be more even. If allowed to cool in the bath there is apt to be a crack at *D*. Polish the die to draw the temper, and do not depend on getting an even temper by drawing the die when it is dirty, as one part may draw faster than another.

Doweling Hardened Parts.

When making pieces such as sections of a built-up die, or any piece having dowel holes, it invariably happens that the dowel holes do not line up after hardening. One way to overcome this trouble is to tap the dowel holes a trifle larger than the dowels to be used, and after the piece is hardened, screw in soft plugs and file them off flush with the

work; when the piece is screwed in its proper place, the dowel holes are drilled and reamed through the soft screw bushings. This will save a great deal of unsatisfactory lapping.*

Construction of Dies to Prevent Breakage in Hardening.

Another method of preventing breakage in hardening of dies with small projecting tongues, as shown in Fig. 70, is to construct the die in the manner outlined below. The die is first filed or machined in the regular way, with the exception that the two tongues are left out. In line with the center of the tongues and at a certain distance from the cutting edge, holes are drilled larger than the width of the tongues. These are taper reamed from the top with a standard taper reamer. A slot is then cut from the holes into the die the same size as the

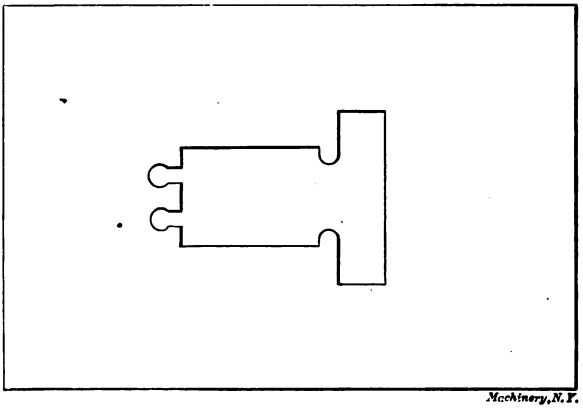


Fig. 71. Method of Making Dies to Prevent Breakage in Hardening.

tongue, when the die would look as shown in Fig. 71. We now make two pieces to fit in the holes, and extend out the required distance, making sure that they will be a drive fit after hardening. It is best if the pieces are 1/32 inch longer than the thickness of the die, so that they can be ground flush after being driven into place. While this may increase the cost of producing the die, yet, if from any accident one or both tongues should be broken, they are easily replaced without the necessity of annealing the die.**

Fig. 72 shows a very good method of making a die that is to contain a number of identically-shaped teeth or points, such as dies for gear blanks, etc. While not being the most accurate method known, it is considered that for all work intrusted to a punch and die the method illustrated will be sufficiently accurate. A set of broaches are made, as shown in the cut, the number of steps being governed entirely by the length, or depth, of the teeth. The pilot fits the hole in the die, which is the diameter at the top of the teeth, and each step on the broach is 0.002 inch larger than the preceding step. The broaches

* F. E. Shailor, March, 1907.
** K. L. Ross, September, 1907.

are made on centers and necked in at *Q* to allow clearance for the chips. With a cutter of the proper shape the teeth are then milled on the broaches, using the dividing head on the miller. After cutting the teeth on all of the broaches, the teeth on the punch should be cut

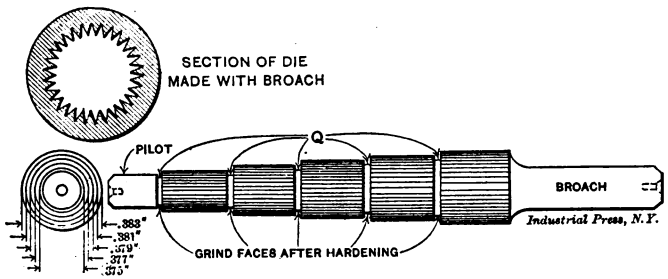


Fig. 72. Broach for making Dies for Gear Blanks, etc.

at the same setting. The broach is then hardened and ground on the faces as indicated. When used, each successive step is driven through the die until the last step is reached, and this should be driven through as many times as there are teeth in the broach, turning it one tooth each time. By doing this, whatever error may have been caused by hardening is overcome.*

* F. E. Shailor, January, 1904.

CHAPTER III.

EXAMPLES OF DIES AND PUNCHES.

In the following are given a few examples of the design and construction of dies and punches, selected because they are very interesting and ingenious in their action. The die in Fig. 73 was designed by Mr. Thomas Gierding, of the New Haven Clock Company. This die performs five distinct operations before the piece shown in the upper left-hand corner of Fig. 73 is dropped completed from the press.

In constructing this die it was not deemed practicable to make it of one solid piece, since one small flaw would, in this case, spoil the entire die. A die block of machine steel was therefore used, having recesses counterbored for the insertion of tool steel bushings. These recesses were accurately spaced by the method illustrated in Fig. 74. One side and one end of the die block were machined perfectly square, and a center line drawn lengthwise on the face of the block. The location of the recesses was approximately laid out with lead pencil and the recess *A* bored in the lathe, by strapping the block to the faceplate. Before loosening the straps by which the block was held, the parallels, *B* and *C*, bearing against the finished edges of the block, were strapped to the faceplate. The straps holding the block were then loosened and the block moved along the strip *C* sufficiently to allow for the insertion of the spacing block, *D*, which had previously been made of the required size. The die block was then fastened and the hole *E* recessed. By repeating this operation, and adding a block each time until all of the recesses were bored, it was possible to space the die far more accurately than would have been possible by the time-honored method of laying it out with dividers. The punch holder and the stripper were then bored in the same manner, using the same spacing blocks.

The bushings *F*, *G*, *H*, *I*, *J*, *K*, were next made, and after being hardened they were lapped to size. The outside of the bushings was ground concentric with the hole by wringing the bushing on a piece of soft steel held in the chuck and turned to fit the hole in the bushing. The bushings were then forced in the die block and the die was completed. The punches were ground all over, to insure straightness, and they, in turn, were forced into the punch holder. The drawing and forming punches *L* and *M* were held with setscrews to prevent them from being pulled out.

In using a die containing two or more punches, considerable trouble is sometimes experienced on account of the variation in width of the stock to be punched. Should the stripper be planed to fit one of the strips of stock very nicely, the chances are that the next strip would not enter the stripper at all. The part, *N*, shown in the plan of the

die, is a novel and practical way in which this trouble is overcome. The stripper is planed out 1/16 inch wider than the stock and recessed to allow the spring guide *N* to slide freely when the stripper is in

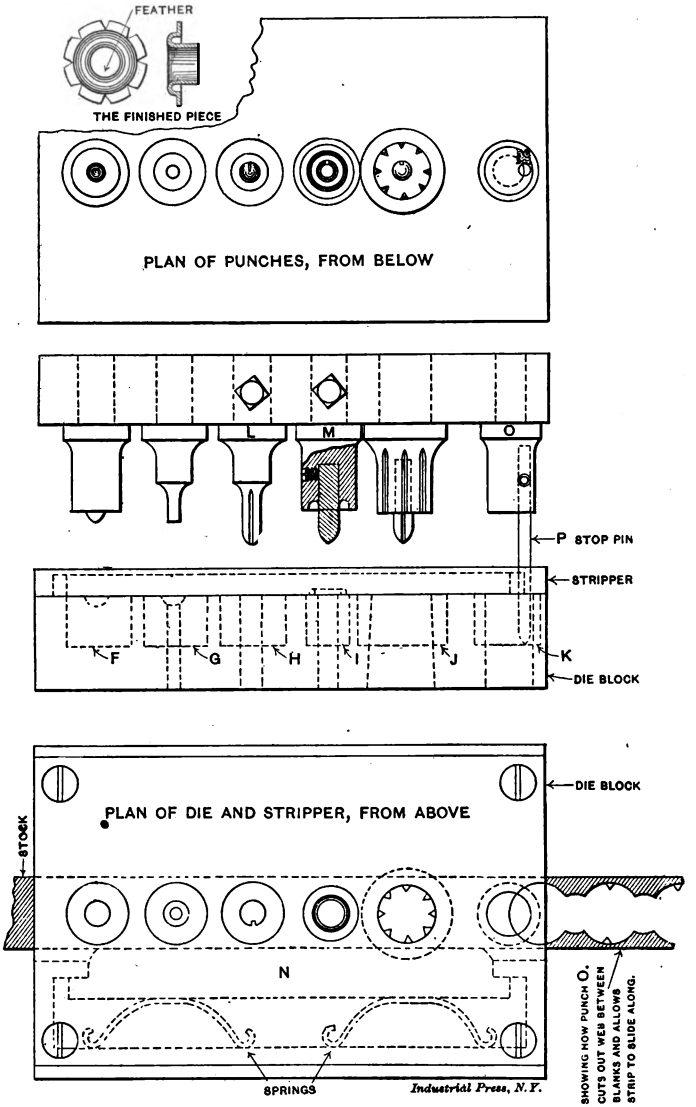


Fig. 73. Punch and Die for Performing Five Distinct Operations.

position in the die. By glancing at the sketch the reader can readily see how the springs keep the stock pressing against the gage side of the stripper. The punch *O* does not perform any work pertaining to

the finished blank, but is used for cutting out the web in the stock in order to allow the strip to move along until the next web touches the stop pin. As the stop pin *P* does not come out of the stock it is therefore impossible to "jump" the stock and make a miscut, which would mean disaster to the drawing and forming punches.

After setting up the die in the press, the punches of course descend five times before a single finished piece appears, but thereafter a finished piece drops at each stroke of the press. The first punch, beginning at the left, indents the stock, and the punch is so adjusted that the face of the punch levels the stock. The second punch pierces the bottom of the indentation. The next punch draws the stock, and at the same time, forms the feather shown in the finished piece. The fourth is the forming punch and the last punch does the blanking.

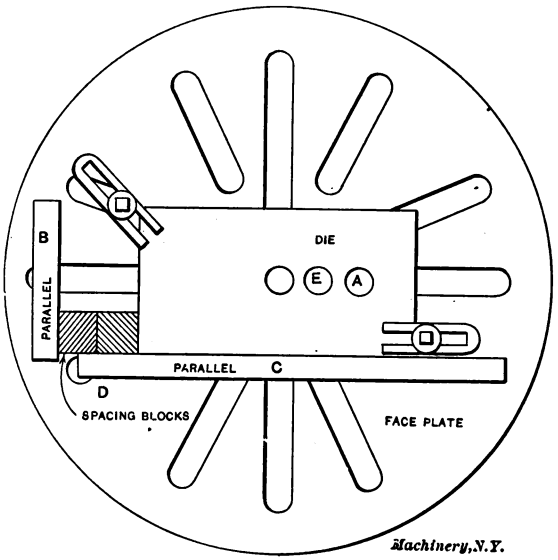


Fig. 74. Spacing the Holes in the Die in Fig. 73.

Another interesting die is shown in Fig. 75. This die contains several novel features that will be found valuable to many engaged in die making. As the sub-press die, the frames, and the power presses are of standard dimensions, it too frequently occurs that a die of a certain size requires specially made frames, and possibly a specially made press. The cut, Fig. 75, shows a practical way to construct a die that not only is a compact self-contained die, but can be fitted to any style of press (of sufficient strength), having any length of stroke.

This particular die was designed to produce the disk shown at *A*, Fig. 76, and previous to its introduction the disks were blanked out with a plain open die and then leveled by hand. The disks are of aluminum, 99 per cent pure, and, therefore, very soft, and as it is very essential that they should run as true as possible, great difficulty was

experienced in leveling them. The corrugating mats *B B* were designed to level the disk and also to set, or stiffen the metal, and they proved a success, for when the disks leave the die they are as nearly level and true as is possible to make, and so stiff that they can be handled quite roughly without injury. The disk was not corrugated its entire surface owing to the fact that the mat would be obliged to act as the blanking punch, and if the corrugations extended clear to the edge of the mat, it could not be sharpened when dull. Therefore the rings *C D* were introduced. The ring *C* acts as the blanking punch, and ring *D* acts as a leveling ring. The die is guided by means of two guide or pilot pins, *E E*, Fig. 76, and as the gate of the press descends, the rings *C D* are the first to act on the stock to be punched, gripping it from above and below and holding the stock securely. Then, as the press continues downward, the rings settle back, still holding the stock, and the mats *B B* grip the blank.

The rubber spring, which is one of the features of the design, exerts an increasing pressure on the metal, pressing it into the corrugations

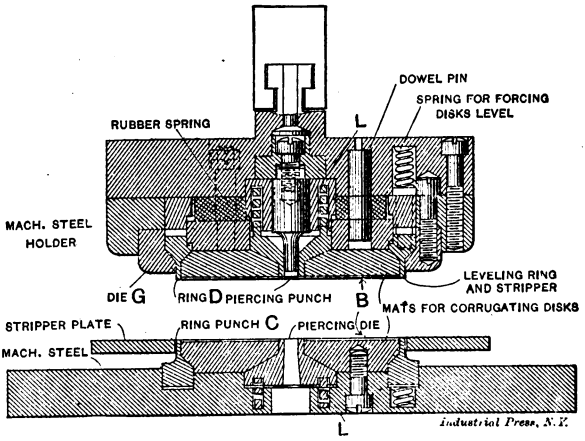
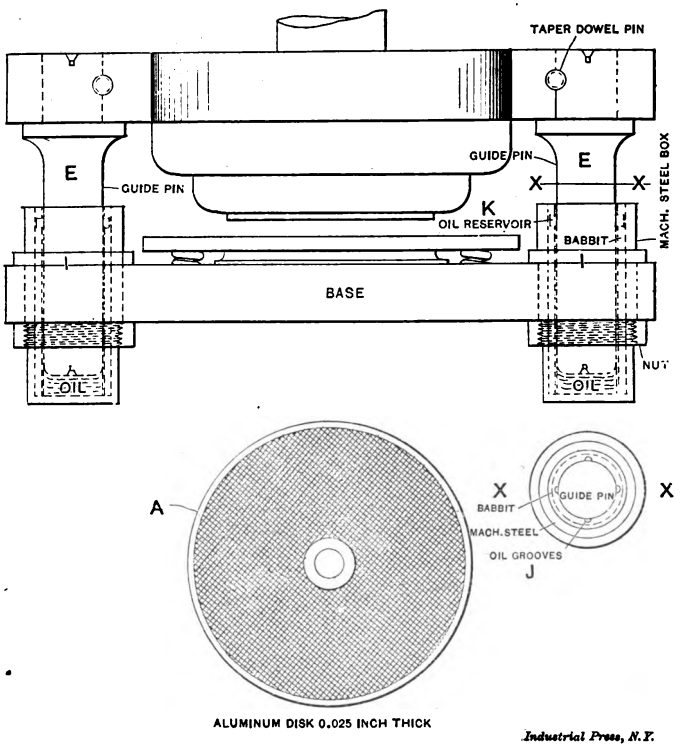


Fig. 75. Vertical Section through Sub-press Die shown in Fig. 76.

on the mats. The press is so adjusted that the ring *C*, which is the blanking punch, comes exactly flush with the die *G*, but does not enter. On the upward stroke of the press, the springs and rubber plate force the moving parts back to their original position, and force the disk out of the die, and the surplus stock off the ring *C*. The rubber plate can be advantageously used in a small place where a very strong spring is required. The tension or spring effect is obtained by cutting holes *H* in the plate, Fig. 77. The more holes there are in the plate, the weaker the tension, as the holes permit the surrounding rubber to squeeze into them. On the other hand if no holes were cut in the rubber plate, and the same fitted the recess in the die bored for it, there would be no more spring effect than if a metal plate were used. Rubber does not compress, but merely changes shape. Another novel feature is

that the guide pins are automatically lubricated at each stroke of the press. The pins run in the babbitt boxes *I I*, Fig. 76, which have four grooves, *J*, cut the entire length of the babbitt, and an oil chamber or reservoir *K* recessed near the top. A quantity of oil is placed in the bottom of the box and as the pins descend they force the oil up through the grooves, *J*, into the reservoir, and as the pins ascend they form a partial vacuum at the bottom of the box, which sucks the oil back to the bottom.

Space will not allow describing the methods employed when making each part of the die, but it will suffice to say that with the exception



Industrial Press, N.Y.

Fig. 76. Side Elevation of Die shown in Section in Fig. 75, and Sample of Work.

of the mats, screws and holder, the parts were hardened and accurately ground, making a smoothly running die. It might be well, however, to mention the method employed in making the square springs *L*.

It is well known what a difficult job it is to wind a heavy coil spring and have it a given diameter on the inside and outside, when finished. A large spring is generally made by heating wire red hot, and winding as many coils as possible before cooling, then reheating and winding more coils. The springs *L L* were made by gripping a

piece of round tool steel in the lathe chuck, turning it to the given outside diameter. The lathe was then geared to cut a coarse pitch thread and with a square thread tool, the thread was cut sufficiently deep. The inside of the spring-to-be was then bored out to the proper diameter, leaving a spring the coils of which are evenly spaced, thereby causing each coil to perform equally its share of the work. With a wound spring the coils are very seldom equally spaced, and when under pressure there is a greater strain on the coils furthest apart, causing the spring to either "set" or break at that point.

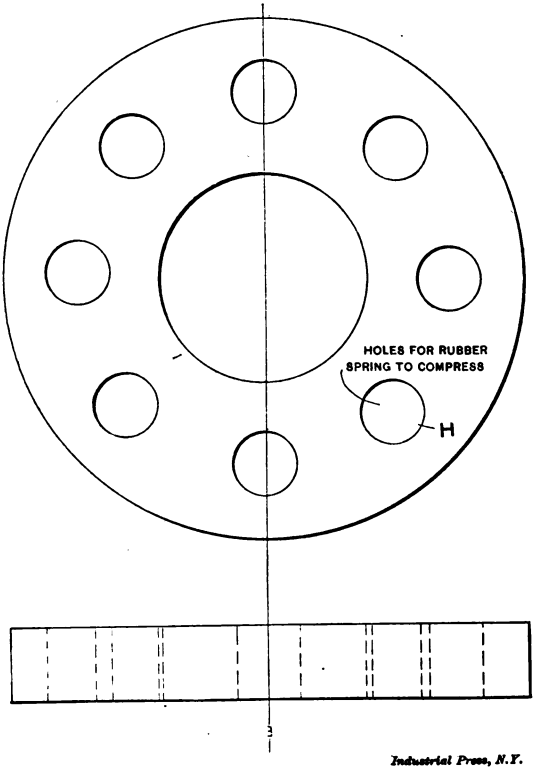


Fig. 77. Spring Rubber Plate.

After all parts of the die were completed, the die was assembled, leaving out the springs. The upper and lower part were then brought together until the punches entered the dies, care being exercised that the upper and lower part of the die were perfectly parallel with each other. The boxes *I I* were then babbitted, first treating the guide pins with a light coating of flake graphite and oil to prevent the babbitt sticking to the pins. The writer considers that a large die of the above description is far superior to the ordinary sub-press die, inasmuch as it

is more compact, and also does away entirely with the cumbersome cast iron frame.

Fig. 78 shows a die that is designed to take the place of the plain, open, double die. The ordinary double die is made with the stripper fastened to the die and planed out to allow the stock to slide through. The unsatisfactory results obtained when using a die of this style are well known. The greatest fault is that no two blanks are exactly alike, owing to the fact that the stock is wrinkled and does not lie level on the die. As the punches descend, they pierce the stock without leveling same, and as the blanks are afterward leveled, it is found that the pierced holes, being unevenly spaced, will not allow the blanks to interchange. By making the die, as shown in Fig. 78, with the stripper plate *M* fastened to the punch-holder and with a stiff coil spring at each corner, and so adjusted that the punches do not come

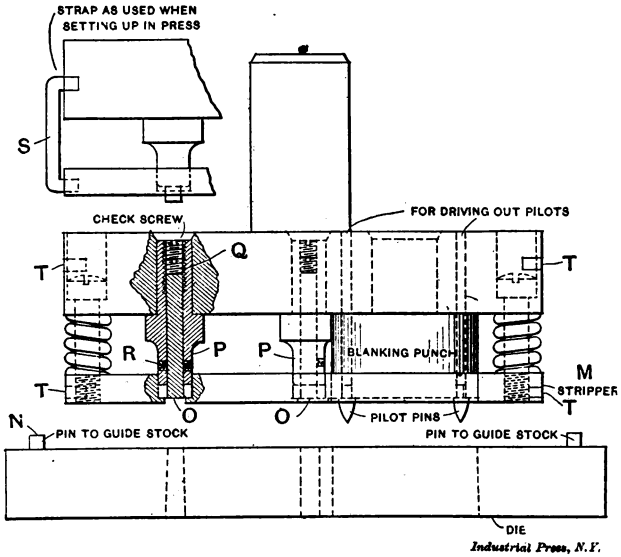


Fig. 78. Die with Stripper Attached to Punch to Flatten Stock.

quite flush with the face of the stripper, the above-mentioned trouble is nearly eliminated. On the downward stroke of the press the stripper *M* presses the stock firmly against the die, holding it level while the punches perform their work. The stock is guided by means of a small pin *N* at each end of die. The stripper should not fit the punches; for if the operator should make a miscut, or should a piece of scrap punching get under the stripper, it would cause it to tilt and bring disaster to the small punches.

Another valuable feature in this die is the manner in which the piercing punches *O O* are constructed. Ordinarily piercing punches are made solid, and if one breaks, it necessitates making a whole new punch or grinding the other punches down to the same length, greatly

shortening the life of the die. The punches shown at *O O* are designed to overcome this trouble. A holder *P* is made and left soft, into which the punch (or rod) *O* is inserted, being backed up by the screw *Q* and prevented from pulling out by means of the screws *R*. Then, should one of the punches "flake" off, that same punch can be ground and then forced out by means of the screw *Q* until it is at the same height as the others. This style of piercing punch greatly increases the life of a die. This die can be made either with or without the guide pins *E E*, in Fig. 76. If made without the guide pins it is necessary to use the straps *S* to allow aligning the punches with the die when "setting up" in the press. The stripper is forced back and the straps inserted in the holes *T T*. After the die is "set up" and securely fastened, the straps are removed.

All presses in which double dies are used should be provided with a separator, which is a piece of sheet metal fastened underneath the press to separate the scrap punchings from the blanks. It is fre-

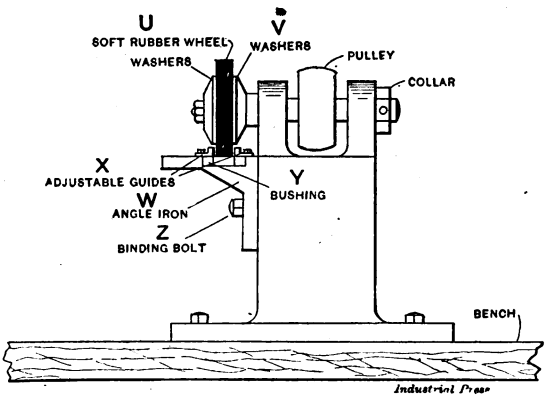


Fig. 79. Machine for Separating Blanks from Stock Strips.

quently noticed that in factories where no separator is used, the cost of sorting the blanks from the scrap is in excess of the cost of blanking. A sub-press die leaves the blanks in a strip of stock. If the stock is over 0.02 inch thick, considerable trouble is experienced in removing the blanks. Fig. 79 shows a means whereby the blanks are forced from the strip without marring them. *U* represents a soft rubber wheel, which is supported on the sides nearly to the edge by the washers *V*. The angle iron *W* is provided with adjustable guides *X* and is recessed at *Y* to receive bushings having different sized holes. A bushing is inserted in the angle iron having a hole somewhat larger than the blanks to be forced out. The guides *X* are then adjusted to allow the strip to slide freely. The angle iron is then raised by loosening the bolt *Z* until sufficient pressure is brought on the rubber wheel. The wheel being power driven, all that is necessary is to place the end of a strip under the rubber wheel and it will roll the strip along, at same time forcing out the blanks.